THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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Chronicle and Comment

Crankcase-Oil Contamination Researches

IN the early spring the Society, cooperating with the American Petroleum Institute and the National Automobile Chamber of Commerce, undertook to collect some 500 samples of contaminated oil from about 50 service-stations located throughout the Country. Seventy-five per cent of these samples have now been received and are being analyzed at the Bureau of Standards.

Aeronautic Meeting, Oct. 7

ON the afternoon and evening of Oct. 7 the annual Aeronautic Meeting of the Society will be held at Hotel Astor, New York City. The afternoon session will be devoted to design and construction whereas the evening session will deal with topics relating to operation. An Aeronautic Dinner will be enjoyed during the interval between the two sessions.

Among those who are expected to present papers at the meeting are H. M. Crane, J. E. Whitbeck, W. B. Stout, W. L. Gilmore and W. L. LePage.

The Transactions

AT practically the same time as this issue of THE JOURNAL is being mailed, copies of Part I of Vol. 19 of the TRANSACTIONS are being sent to the members who have placed orders for them. The papers presented at the 1924 Annual Meeting, together with papers presented at Sections Meetings and printed in the January to June, 1924, issues of THE JOURNAL inclusive, that were considered by the Publication Committee to possess sufficient engineering value to warrant reprinting, are included in this part of the TRANSACTIONS together with the discussion of the papers. The volume consists of 737 pp. The number of papers included therein is 28.

November Meetings

CONSIDERABLE progress has been made in the arrangements for the annual Transportation Meeting that will take place in Philadelphia, Nov. 12 and 13. The Benjamin Franklin Hotel has been chosen for headquarters. Operation phases will be discussed at sessions devoted to standardization, freight handling, store-door delivery, car consolidation, motorcoaches, and gasoline-electric developments. An inspection trip, a street parade and a Transportation Dinner will be included in the program of events.

At the Service Engineering Meeting to be held in cooperation with the National Automobile Chamber of Commerce, two sessions will be under the sponsorship of the Society. These will in all probability be devoted respectively to the discussion of corrosion and the diagnosis and remedying of troubles.

Additional details concerning both of these meetings will be published in later issues of THE JOURNAL and in the *Meetings Bulletins*.

Highways Committee Progress

THE Highways Committee of the Society, which is cooperating with the Bureau of Public Roads and the Rubber Association of America, met in the City of Washington on Aug. 10. The object of the meeting was to discuss the results obtained through researches on motor-truck and tire impact-tests carried out at the Bureau of Public Roads. The present results have been obtained for the purpose of comparing the cushioning qualities of various solid and cushion tires. If, through further investigation or comparisons, the results obtained prove to be fundamentally correct not only for comparative purposes but even so far as numerical values of impact forces are concerned, some very useful general data could be furnished to the industry. Knowledge of exact numerical values of road impacts should be of very great value in the calculation of stresses in tires, axles, springs and other parts of the chassis as well as the body.

For reasons of economy and convenience it is necessary to build automobiles lighter. This requires a reduction of factors of safety to the minimum which can be determined only by an exact knowledge of stresses.

Production Meeting Plans

SIX technical sessions of unusual interest have been provided for the annual Production Meeting by the committee in charge. Two of these sessions will relate to machine-tool topics, whereas others will deal with the production phases of gears and sheet steel. The training of foremen and mechanics and inspection will be the topics under discussion at the two remaining sessions.

The committee has succeeded in arranging a program that fully complies with the intent of the slogan, "A Production Meeting for Production Men." The details together with the list of speakers will be found on p. 222 of this issue of THE JOURNAL.

The National Steel Exposition arranged by the American Society for Steel Treating will offer to our members an interesting attraction. A large portion of the exposition will be devoted to machine-tool exhibits, many of which will be in actual operation under production conditions. This exposition, the largest of its kind in the world, will demonstrate the complete cycle of operations from raw material to finished product.

A number of attractive social events have been planned for both ladies and gentlemen. Among these the Production Dinner will be of outstanding interest. The committee has had the good fortune to obtain K. T. Keller, vice-president and general manager, General Motors of Canada, Ltd., as the principal speaker at the dinner. President Horning will preside.

The Society will enjoy cooperation with the American Society for Steel Treating which holds its Seventh Annual Convention in Cleveland concurrently with the Production Meeting. Invitations to members of the two societies to attend the technical sessions and entertainment events throughout the week have been interchanged.

Standards Approved and Data Sheets Issued

FOLLOWING the adoption by letter-ballot of the voting members of the specifications approved at the Summer Meeting of the Society, data sheets were mailed to the members in August setting forth the new and revised specifications. The complete report of the Society letter-ballot on the adoption of the standards is given on p. 226 of this issue.

Standardization Activities

THE section on Standardization Activities that appears in THE JOURNAL each month is intended to afford interested members a means of keeping in close touch with any standardization projects appplying to their particular fields. It is often thought, however, that specifications are not printed in this section until they are finally approved by the respective Divisions sponsoring them. If this were the case, the specifications when approved by the Society would be fairly subject to criticism on the basis of their not representing the consensus of opinion of the industry. To avoid such criticism, it is the policy of the Society to publish each month such Subdivision or preliminary reports as are submitted, as well as the final reports approved by Divisions. Thus, it often occurs that a given specification will appear several times in THE JOURNAL before it is finally approved by the Society. Comment on, and criticism of, the specifications during their formative stage will be greatly appreciated by the Divisions and Subdivisions.

In addition to strictly Society standardization, general standardization of interest to automotive engineers and matters closely related to standardization are reported. The article on p. 225 of this issue setting forth the action of the State of Massachusetts in limiting maximum permissible head-lamp illumination in that Commonwealth is an example of such information.

Copies of the reports printed in THE JOURNAL are mailed to engineers connected with the various automotive vehicle and parts manufacturers that would be affected by the various standards proposed. The comments received in response to these direct requests for criticism constitute a most valuable basis for procedure in the revising of preliminary reports. Criticism of others interested in the Standards work is appreciated, but contact with such a great number can be maintained only through the Standardization Activities pages.

Production and Resources of Gasoline

IN a recent report of the Department of Commerce it was stated that the American production of gasoline has grown from less than 1,500,000,000 gal. in 1914 to nearly 9,000,000,000 gal. in 1924, an increase of 500 per cent. The relative importance of the United States in the gasoline industry is emphasized by the fact that our per capita annual consumption totals 69.3 gal., while in the United Kingdom, the next largest consumer of gasoline, the average is 11.6 gal. In a report recently issued in book form by the American Petroleum Institute, the opinion is expressed on behalf of directors of that organization that a sufficient supply of motor fuel and lubricants is assured for the National defense and for essential uses beyond the time when science will limit the demand by developing more efficient use of, or substitutes for, oil, or will displace its use as a source of power by harnessing a natural energy. Petroleum recoverable by present methods of flowing and pumping from proved acreage is estimated to amount to 5,300,000,000 bbl. Furthermore, it is averred that, after pumping and flowing cease, 26,000,000,000 bbl. of oil, a considerable portion of which can be recovered by improved and known processes, will remain in the area now producing or proved. The major oil-reserves of the United States are understood to lie in some 1,100,000,000 acres of land that is underlain by sedimentary rocks and not fully explored. Improved methods of deep drilling should disclose many deposits not before available.

With reference to the vast deposits of oil shale, coal and lignites, from all of which liquid fuel and lubricants can be extracted if and when the cost of recovery shall be supported by demand, these are said to constitute an almost unlimited supply. In general, it is stated that predictions of future supply of crude oil are necessarily conjectural; in addition, that estimates of future demands, which depend upon conditions which, with the advance of science and invention, may undergo unforeseen and radical changes, are clearly speculative.

The burden of the report is that no imminent danger of the exhaustion of the petroleum reserves of this Country exists. The observation is made that current supply and demand cannot remain in balance, in view of the fact that the amount of both changes constantly; in a general way, current supply will exceed or be less than current demand, creating surplus or shortage, either condition being reflected in price; but in time price will correct either condition.

Countries in the southern portion of this hemisphere are known to have large petroleum resources. For these the United States is a natural market and the supply therefrom will inevitably influence the consumption of American reserves.

Automotive engineers are quoted in the report as stating that the mileage of automobiles per gallon of gasoline can be doubled through structural mechanical changes when these are justified by price; and, moreover, that improvements will result in smaller consumption of lubricants.

The prediction is made that the supply of gasoline will be further augmented by the cracking of fuel oil; the supply of fuel oil consequently being correspondingly diminished, thus eventually eliminating fuel oil from competition with coal.

MEETINGS OF THE SOCIETY

PRODUCTION MEETING ANNOUNCEMENTS

Six Technical Sessions and Other Features Will Draw Crowd to Cleveland

Production men throughout the Country will be attracted by the events scheduled for the Society's fourth annual Production Meeting that is to be held in Cleveland, at the Hotel Winton, Sept. 14, 15 and 16. Even a casual perusal of the Production Meeting program that appears in this issue of THE JOURNAL will tend to indicate the truth of this statement, and a more thorough study will convince the production engineer that he must make every possible effort to attend the meeting.

TECHNICAL SESSIONS

Sheet-steel fabrication, the training of foremen and mechanics, gears, machine tools and inspection are the topics that will be discussed at the six technical sessions; and each paper at these sessions will be given by a person so thoroughly acquainted with his subject as to assure that the treatment will be as practical and concrete as the topic under consideration.

A wealth of data and ideas will be presented through the medium of the papers that compose the formal program, and it is anticipated that much valuable information may be gained by a participation in the discussion that will be an integral and lively part of each session. No session will be so crammed with papers that discussion will be crowded into a few hurried minutes or even eliminated.

PLANT INSPECTION

Many members who are planning to attend the Production Meeting have expressed a desire to visit one or more of the industrial points of interest in which Cleveland abounds. It is believed that many will take advantage of the opportunity that will be afforded to make one or more inspection trips. Cleveland manufacturers will maintain open house for members who care to inspect the plants.

COOPERATION

Time has been allowed too for inspection of the exhibits of the National Steel Exposition that is to be held in the Public Auditorium under the auspices of the American Society for Steel Treating. Our Society is cooperating with the American Society for Steel Treating which holds its Seventh Annual Convention concurrently with our Production Meeting. Invitations to attend sessions and participate in the various social events of the two Societies have been interchanged.

ENTERTAINMENT FEATURES

Mindful of the deleterious effect that "all work and no play" is said to have, the Committee in charge of the Production Meeting has scheduled various affairs of a social character. The Production Dinner will take place at the Hotel Winton on Tuesday evening, Sept. 15. The Committee has had the good fortune to obtain the consent of K. T. Keller, vice-president and general manager, General Motors of Canada, Ltd., to speak at the dinner, and his message will be one of vital interest to production men.

Order blanks for the dinner formed a part of the *Meetings Bulletin* that was mailed to all members on Aug. 18. Tickets will be $3.50 each, for members and non-members. Prior to Thursday, Sept. 10, orders for dinner tickets should be mailed to Society headquarters, 29 West 39th Street, New York City. After that date, orders should be addressed to Society of Automotive Engineers, Hotel Winton, Cleveland. Tickets will be on sale at the hotel until 6 p. m., Sept. 15. No tickets can be cancelled or refunds granted after Friday, Sept. 11. At the Production Dinner, all seats will be reserved, and preference as to location will be accorded applications in the order of their receipt. Each table seats eight persons; if you wish to make up your own party, send in one application for the entire group of tickets. The dinner is to be informal, and the wearing of evening clothes is discouraged.

Through the courtesy of the American Society for Steel Treating, our members have been invited by that organization to attend a smoker and frolic on Tuesday evening and a Grand Ball that will take place, Wednesday evening, at the Hotel Cleveland.

A golf tournament will be one of the attractions of the week. All members who desire to participate should at once notify W. F. Abel, 2589 Euclid Boulevard, Cleveland, giving their name, firm name and address; also their average score for four games of 18 holes each. The tournament will begin on Tuesday morning and will end on Thursday morning. Each player will take care of his green fees and caddy.

The ladies who accompany their husbands to Cleveland will find themselves well entertained, as numerous functions have been planned especially for them, including luncheons, drives, a theater party and, of course, the Grand Ball already mentioned.

RECORD ATTENDANCE EXPECTED

Because of the comprehensiveness of the program, the broad interest in the topics to be considered, the authoritative treatment that will be accorded them and the valuable discussion that will be brought out at the sessions, it is believed that an unusually large number of production men will be attracted to the meeting. Non-members of the Society are cordially invited to attend the technical sessions of the Production Meeting; a registration fee of $1 will be charged. Members of the American Society for Steel Treating will be admitted free of charge upon showing their badge.

REDUCED RAILROAD FARES

Members of the Society and their families may purchase round-trip tickets for fare and a half. A certificate entitling them to this privilege will be mailed to the entire membership with the *Meetings Bulletin* that will be issued about 2 weeks in advance of the meeting.

NATIONAL STEEL EXPOSITION

Exhibits Will Show Complete Cycle from Raw Material to Finished Product

The great Cleveland Public Auditorium has been entirely reserved by exhibitors for the National Steel Exposition that will be staged by the American Society for Steel Treating during the week of Sept. 14, concurrently with its Seventh Annual Convention and our Society's fourth annual Production Meeting. According to a statement issued by the American Society for Steel Treating, this will be the largest exposition that it has ever held and the largest steel exposition

ever held in the world. Both of the extensive floors of the Auditorium, as well as the stage, have been reserved by exhibitors who will have their products on display.

Members attending the Production Meeting will be glad of the opportunity to visit the Steel Exposition which will represent a complete cycle in the metal working and the metal treating industry. The raw material will be shown in one section. Another division will be occupied by 90 builders of machine tools who will have their equipment in operation. In the heat-treating department, manufacturers of heat-treating equipment and materials will have their products on display and in operation. In still another section, inspection tools and equipment will be shown by numerous manufacturers. Thus, the complete cycle will be shown, from the raw material to the finished product. A partial list of exhibitors is given below.

MANUFACTURERS OF MACHINE TOOLS AND SMALL TOOLS

Abrasive Machine Tool Co.
Acme Machine Tool Co.
Allen, Charles G.
American Tool Works Co.
Ames, B. C.
Armstrong-Blum Mfg. Co.
Atkins & Co., Inc., E. C.
Avey Drilling Machine Co.
Badger Machine Tool Co.
Baker Bros.
Bath & Co., John
Black & Decker Mfg. Co.
Blanchard Machine Co.
Brown & Sharpe Mfg. Co.
Bullard Machine Co.
Campbell Co., A. C.
Cincinnati Bickford Machine Co.
Cincinnati Grinder Co.
Cincinnati Milling Machine Co.
Cincinnati Planer Co.
Cincinnati Shaper Co.
Cleveland Automatic Machine Co.
Cleveland Twist Drill Co.
Davenport Machine Tool Co.
Disston & Sons, Inc., Henry
Ex-Cell-O Tool & Mfg. Co.
Gardner Tap & Die Co.
Geometric Tool Co.
Giddings & Lewis
Gisholt Machine Co.
Goddard & Goddard Co.
Goss & DeLeeuw Machine Co.
Gould & Eberhardt, Inc.
Gray Co., G. A.
Hammond Mfg. Co.
Hanson-Whitney Machine Co.
Heald Machine Co.
Heim Grinder Co.
International Machine Tool Co.
Jones & Lamson Machine Co.
Kearney & Trecker Corporation
Keller Mechanical Engineering Corporation
King Machine Tool Co.
Knight Machine Co., W. B.
Kobert Machine Co.
Landis Tool Co.
Leland-Gifford Co.
Liberty Machine Tool Co.
Lodge & Shipley Machine Tool Co.
Lucas Machine Tool Co.
Marschke Mfg. Co.
Minster Machine Co.
Monarch Machine Tool Co.
Morris Machine Tool Co.
Morse Twist Drill & Machine Co.
Motch & Merryweather Machinery Co.
National Automatic Tool Co.
National Twist Drill & Tool Co.
New Britain Machine Co.
Newmann's Successors, Inc., Friederich
Niles-Bement-Pond Co.
Norton Co.
O. K. Tool Co.
Oesterlein Machine Co.
Oilgear Co.
Peerless Machine Co.
Pels & Co., Henry
Potter & Johnston Machine Co.
Pratt & Whitney Mfg. Co.
Production Machine Co.
Ransom Mfg. Co.
Rockford Machine Tool Co.
Rockford Milling Machine Co.
Sebastian Lathe Co.
Seneca Falls Machine Co.
Simonds Saw & Steel Co.
Stamets, William K.
Standard Tool Co.
Starrett Co., L. S.
Strong, Carlisle & Hammond Co.
Taylor & Fenn Co.
Thompson Co., Henry G.
Union Twist Drill Co.
Universal Grinding Machine Co.
V & O Press Co.
Walcott Lathe Co.
Walker Co., O. S.
Warner & Swasey Co.
Whitney Mfg. Co.
Wilmarth & Morman Co.

METALS AND METAL-TREATING, TESTING AND INSPECTION EQUIPMENT

Air Reduction Sales Co.
American Gas Furnace Co.
American Resistor Co.
American Stainless Steel Co.
Andresen & Associates, F. C.
Armstrong Cork & Insulation Co.
Atlas Alloy Steel Corporation
Bausch & Lomb Optical Co.
Bellevue Industrial Furnace Co.
Bellis Heat Treating Co.
Bethlehem Steel Co.
Bristol Co.
Brown Instrument Co.
Brown Lynch Scott Co.
Bureau of Standards
Carborundum Co.
Carpenter Steel Co.
Case Hardening Service Co.
Celite Products Co.
Central Steel Co.
Colonial Steel Co.
Cooper Hewitt Electric Co.
Crucible Steel Co. of America
Davidson Gas Burner & Welder Co., N. C.
Dearborn Chemical Co.
Donner Steel Co.
Driver-Harris Co.
Electrical Refractories Co.
Electro Alloys Co.

PRODUCTION MEETING PROGRAM

Monday, Sept. 14

Morning

REGISTRATION AND ASSIGNMENT TO ROOMS
Time to meet your friends and to visit the National Steel Exposition at the Public Auditorium

Afternoon

SHEET-STEEL FABRICATION SESSION
Hot Stamping Methods—G. F. Keyes, Mullins Body Corporation
Sheet-Steel Fabrication—Syd Smith, Studebaker Corporation of America

TRAINING SESSION
Training of Mechanics for Production Work—Mrs. Lillian M. Gilbreth, Frank Gilbreth Co., Inc.
Foreman Training and the Value of Conferences—F. T. Jones, White Motor Co.
The Training of Shop Foremen—Louis Ruthenburg, Yellow Sleeve Valve Engine Works, Inc.

Evening

INSPECTION OF NATIONAL STEEL EXPOSITION
Exhibits showing processing from raw material to finished product at the Public Auditorium

Tuesday, Sept. 15

Morning

GEAR PRODUCTION SESSION
Coordinating Designs and Production Methods in Gear Development—P. L. Tenney, Muncie Products Division, General Motors Corporation
The Problem of Gear Production—Earle Buckingham, Niles-Bement-Pond Co.

Afternoon

MACHINE TOOL SESSION
Machine-Tool Needs of the Automotive Industry—R. M. Hidey, White Motor Co.
Machine-Tool Selection—W. G. Careins, Ajax Motors Co.

Evening

PRODUCTION DINNER
Address by K. T. Keller, Vice-President and General Manager, General Motors of Canada, Ltd.
Smoker and Frolic with American Society for Steel Treating

Wednesday, Sept. 16

Morning

MACHINE-TOOL SESSION
Machine-Tool Applications to Automotive Production—A. R. Kelso, Continental Motors Corporation
Jigs and Fixtures in Automotive Production—J. Gustaf Moohl, Cleveland Automobile Co.

Afternoon

INSPECTION SESSION
Inspection Methods—C. J. Ross, Buick Motor Co.
Inspection Aspect in the Airplane Industry—J. J. Feeley, Glenn L. Martin Co.

Evening

GRAND BALL
American Society for Steel Treating and Society of Automotive Engineers

All technical sessions will be open to members of the Society of Automotive Engineers and the American Society for Steel Treating. Non-members will also be welcome; they will be charged a registration fee of $1.

NATIONAL MEETINGS CALENDAR

PRODUCTION MEETING AND EXPOSITION—Cleveland—Sept. 14, 15 and 16

AERONAUTIC MEETING—New York City—Oct. 7

AUTOMOTIVE TRANSPORTATION MEETING—Philadelphia—Nov. 12 and 13

SERVICE ENGINEERING MEETING—November

ANNUAL DINNER—New York City—Jan. 14, 1926

ANNUAL MEETING—Detroit—Jan. 20, 21 and 22, 1926

Englehard, Inc., Charles
Firth-Sterling Steel Co.
Ford Co., J. B.
Forging-Stamping-Heat Treating
Ganschow Co., William
Gathmann Engineering Co.
General Alloys Co.
General Electric Co.
Hagan Co., George J.
Halcomb Steel Co.
Heppenstall Forge & Knife Co.
Hevi-Duty Electric Co.
Holcroft & Co.
Hoskins Mfg. Co.
Houghton & Co., E. F.
International Nickel Co.
Interstate Iron & Steel Co.
Iron Age Publishing Co.
Jessop Steel Co.
Jones & Laughlin Steel Corporation
Keystone Lubricating Co.
King Refractories Co.
Leeds & Northrup Co.
Leitz, Inc., E.
Ludlum Steel Co.
Midvale Co.
National Electric Light Association
Nuttall Co., R. D.
Ohio Steel Foundry Co.
Olsen Testing Machine Co., Tinius
Oxweld Acetylene Co.
Park Chemical Co.
Penton Publishing Co.
Pittsburgh Crucible Steel Co.
Pittsburgh Instrument & Machine Co.
Quigley Furnace Specialties Co.
Republic Flow Meters Co.
Rockwell Co., W. S.
Rodman Chemical Co.
Roessler & Hasslacher Chemical Co.
Shore Instrument & Mfg. Co.
Skybryte Co.
Spencer Turbine Co.
Strong, Carlisle & Hammond Co.
Sun Oil Co.
Swedish Crucible Steel Co.
Swindell & Bros. Co.
Taylor Instrument Companies
Timken Roller Bearing Co.
United Alloy Steel Corporation
Vanadium Alloys Steel Co.
Westinghouse Electric & Mfg. Co.
Wheelock, Lovejoy & Co., Inc.
Wilson-Maeulen Co.

The members of the Society have been extended a special invitation to visit the Exposition, and it is felt that it will appeal to all as one of the big attractions of the week. The Production Meeting program has been so arranged as to allow ample time for a satisfactory inspection of the many interesting exhibits.

OTHER NATIONAL MEETING PLANS

Preliminary Announcements About Aeronautic, Transportation and Service Meetings

The Aeronautic Meeting will be held at the Hotel Astor, New York City, on Oct. 7, the day before the beginning of the Pulitzer Prize Race Meet. Two technical sessions are being planned, one to convene in the afternoon, the other in the evening, with dinner between the sessions. One session will deal with design and construction; the other, with operation. Past-President Crane has agreed to act as toastmaster at the Aeronautic Dinner.

At the Transportation Meeting, which will be held at the Benjamin Franklin Hotel, Philadelphia, Nov. 12 and 13, the three technical sessions will be devoted respectively to Standardization, Freight Handling and Store-Door Delivery, and Motorcoaches. Several interesting papers have been promised and others will be forthcoming. One afternoon will be devoted to an inspection of the plant and the equipment of the Philadelphia Rural Transit Co. A Transportation Dinner will be the chief social event of the meeting.

The time and the place for the Service Engineering Meeting are as yet unsettled. It will doubtless be held during November, in cooperation with the National Automobile Chamber of Commerce, as has been the custom. Two technical sessions are being planned as the Society's part of the program, one on corrosion and one on the diagnosing of troubles and the application of suitable remedies.

Further announcements regarding these meetings will appear in subsequent issues of THE JOURNAL and in forthcoming *Meetings Bulletins*.

SCHEDULE OF SECTIONS MEETINGS

Two Sections have announced meetings to be held in September. The Pennsylvania Section plans to visit the Naval Aircraft Factory at the League Island Navy Yard, Philadelphia, on Thursday afternoon, Sept. 10, at 1:30 p. m. After an inspection of the factory, a paper on Problems Encountered in Testing Aircraft Engines will be read by J. H. Geisse, junior engineer of the Naval Aircraft Testing Laboratories. The Pennsylvania Section has extended to the Metropolitan Section a cordial invitation to join in this meeting.

Dr. H. C. Dickinson, of the Bureau of Standards, will address the Washington Section at its meeting at the Cosmos Club on Sept. 11. His subject will be Driving Safely.

MOTORBOAT MEETING INFORMAL

Problems of Interest to Motorboat and Other Automotive Engineers Discussed

A variety of topics, more or less closely allied to the general subject of marine engineering, entered into the discussion at the Society's annual Motorboat Meeting which was held at the Commodore Hotel, New York City, Aug. 27. Second Vice-President Carlson, the chairman of the meeting, regretfully announced that, at the last minute, word had been received that George F. Crouch was unavoidably prevented from attending and addressing the meeting, as had been planned.

STANDARDIZATION NEEDED

Chairman Carlson expressed the opinion that the motorboat industry is on the threshold of a bright future but felt that more interest should be shown in standardization.

C. A. Carlson

C. M. Manly

Past-President Manly agreed with Chairman Carlson in this opinion and indicated the opportunity for increased cooperation of the Society with motorboat engineers by pointing out the relation of marine work to other forms of automotive engineering. Motorboat engineers, like all persons in the automotive field, are concerned with improvements in the internal-combustion engine; because of this common interest, each group can learn many things from the others. All are concerned with problems of reliability, accessibility and possible reductions in the first cost of the apparatus itself. Stating that anything that helps to solve fuel problems or lubrication difficulties is of interest to all members of the automotive profession, Mr. Manly called attention to the research work that has been done by the Society in these and other directions that would be helpful to motorboat engineers. He pointed out that, although much helpful research work has been done, much remains to be done. He stressed the idea that all branches of the automotive-engineering profession should assist in obtaining a fund of really basic information of common helpfulness and emphasized the importance of cooperative effort in research work, all agencies contributing their findings for the benefit not only of other engineers in their own branch but of the engineers in allied fields.

Irwin Chase introduced his interesting remarks by saying that to talk about standardizing motorboats would be to repeat things already stated many times. Pointing out that certain limits of size and other features are imposed by the purpose for which a boat is to be used, he doubted the practicability or advisability of having the actual types of boat standardized, but stated that innumerable details could be standardized to the advantage of all concerned. Mr. Chase emphasized the fact that the most important thing for motorboat companies to do is to interest people in motorboats. An essential factor in creating that interest is to reduce the cost. Such reduction would come from increased production, which in turn would result from standardization not only of the product and the parts thereof but standardization of the equipment used in manufacturing. He referred to the Society's work in standardization as being very beneficial to the industry.

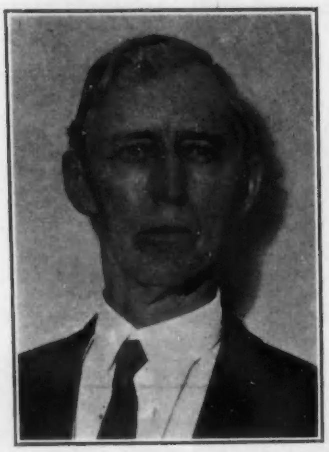
Irwin Chase

F. R. Still

Further reference to the subject of standardization was made by S. R. Dresser, who spoke of the apparent need for it in the electrical line. He expressed a desire for the Society to undertake work that would be helpful in connection with motorboat lamp and socket standardization.

The Gold Cup Races

Because of the prevailing interest in the Gold Cup Races at Manhasset Bay, Chairman Carlson asked F. R. Still, chairman of the Gold Cup Committee, to tell about the races. Mr. Still briefly and interestingly traced the history of the American Power Boat Association from the time of its organization in 1902, through its incorporation in 1918, down to the present time. It is composed of about 150 clubs, with about 60,000 club members. The Association is not a racing organization but a rule-making organization, and is also active



W. H. Fauber

Gerald T. White

in regard to legislation affecting the interests of its members. He told about the gold cup that was given by the Columbia Yacht Club in 1904 as a perpetual trophy. The winning boat at that time had a speed of 23.6 m.p.h., and the speed has increased year by year up to the present record of more than 80 m.p.h.

Application of the Hydroplane Principle to Motorboats

In discussing the subject of the Commercial Field and Future of the Hydroplane in the Motorboat Industry, W. H. Fauber was very optimistic regarding the possibilities of applying the hydroplane principle to motorboat construction. This view was based upon the fact that the hydroplane had eliminated the displacement type as a high-speed motorboat and also upon the adoption of the hydroplane principle by various governments for airplane construction. Another point to be considered by the industry was the development of the so-called surface flying boat.

The hydroplane principle could be adopted for runabouts and light cruisers. Whether the multi-step design was or was not the fastest construction was a question. The main problem confronting the motorboat designer was to produce a craft that was capable of maintaining with safety a high rate of speed in rough water. With increased speed a greater degree of care in construction was necessary. At present the United States is the leading country in motorboat development because of our numerous rivers. If the industry would look well into the future, Mr. Fauber believed that the adaptation of the hydroplane principle to the motorboat

(*Concluded on p.* 230)

STANDARDIZATION ACTIVITIES

The work of the Divisions and Subdivisions of the S. A. E. Standards Committee and other standards activities are reviewed herein

JULY DATA SHEETS ISSUED

Aeronautic Standards Withheld Owing to Changes Approved at Army-Navy Conference

The July, 1925, issue of data sheets containing the specifications approved at the Summer Meeting of the Society were mailed to the members during August. The issue did not include the Army-Navy Standards proposed by the Aeronautic Division for publication in the S.A.E. HANDBOOK, as these specifications were withheld owing to several changes that were made by the Army-Navy Conference held at McCook Field on July 20. A definite system of numbering the Army-Navy Standards was approved at this conference. The specifications withheld from publication in the S.A.E. HANDBOOK will, doubtless, be renumbered in accordance with the new system. The revised specifications will be included in the next issue of data sheets.

Members using the S.A.E. HANDBOOK in their work should have their Handbooks checked completely against the data-sheet list dated July, 1925, which is included in the current issue of data sheets. As the printing dates given under the emblem that appears on both sides of each data sheet are the same, it is necessary to compare only the right-hand-page numbers with the dates given for these page numbers in the check list. Unless such a check is made, the members will have no assurance that their Handbooks are uptodate, and obsolete specifications might, therefore, be used unwittingly.

HEAD-LAMP ILLUMINATION SPECIFIED

Massachusetts Limits Maximum to 50,000 Cp.; Still Lower Limit Forecast

Frank A. Goodwin, registrar of motor vehicles in the State of Massachusetts, has sent out a general notice to the manufacturers of head-lamps approved for use in Massachusetts to the effect that the maximum limit which will be permitted in the future for the beam intensity in Massachusetts will be 50,000 cp. Mr. Goodwin's notice also indicates that head-lamp manufacturers may expect a still lower limit of 30,000 cp. sometime in the future. A maximum limit for the beam candlepower, which is not specified in either the present Illuminating Engineering Society or S.A.E. Specifications, was suggested by J. H. Hunt in his discussion of H. M. Crane's paper on head-lamp illumination at the May meeting of the Metropolitan Section, and had been discussed by the Lighting Committee of the Illuminating Engineering Society and the Society. This is the first case, however, in which it has been definitely sponsored by an authority on head-lamp illumination. In view of the interest now being taken in adequate and safe road illumination Mr. Goodwin's notice is reprinted herewith in full.

MEETING ROOM FOR SUBDIVISIONS AND DIVISIONS OF THE S.A.E. STANDARDS COMMITTEE AT THE NEW YORK CITY HEADQUARTERS
Adequate Facilities Are at the Service of the Standards Committee Members in the Standards Department Office in the New York City Society Office for Holding Division and Subdivision Meetings. The Meeting Room Is Also at the Disposal of Members Desiring To Use It as Headquarters While in New York City. The Secretarial Work of the Standards Committee Is Carried on in This Office

Recently we sent out a notice[1] to the effect that in the future no devices would be approved other than complete head-lamps. This will unquestionably result in a very great improvement in night-driving conditions at such time as the complete head-lamps, as approved, are universally used. In the meantime it is not our intention to permit conditions to continue to exist which may be cured by a re-design of lenses or reflectors, or by the better construction of head-lamps.

Precedent has in the past slowed-down improvement until experience has shown that certain changes in the requirements were absolutely justified. We are convinced from our experience that a limitation of the maximum beam-intensity to a reasonable amount is now justified and will result in material improvement by the resultant reduction of contrast in the beam and the reduction of glare. An examination of the laboratory reports of devices that have been approved in this State shows that the maximum beam-intensities vary from 23,000 to 96,000 cp. In most of these cases the maximum intensity is not usefully employed but is merely incidental to an attempt to make the device comply with the standard specifications without proper designing. Contrast vitally affects good illumination and glare and its elimination is sufficient reason for the limitation of maximum beam-intensity.

Under ordinary circumstances cars equipped with legal devices that are properly adjusted for focus and aim will not glare, but occasions always arise, particularly on the crowns of hills, when the operators of approaching cars are bound to receive the maximum intensity of the beam directly in their eyes. Again, even with the best enforcement of the law, a large number of owners or operators will not or cannot properly adjust their head-lamps. Either of these two circumstances makes it necessary that no greater intensity be permitted in any part of the beam than is necessary to light the highway properly for safe operation. This reduction of glare is also sufficient reason in itself for the limitation of the maximum beam-intensity.

It has been proved that a maximum of 30,000 cp. is amply sufficient for safe driving with properly designed devices or head-lamps. It is possible that a further limitation of the maximum may be specified at some time in the future and the designers of head-lamps should bear that in mind. For all headlighting devices heretofore approved, however, we are now setting the maximum limitation at 50,000 cp. and all manufacturers of devices having a candlepower in excess of this amount at any point in the beam will be required to re-design them and change all tools for production of them before Jan. 1, 1926, or suffer the revocation of their approval. The manufacturers of such devices are being notified individually by letter where such changes are required.

REPORT ON PLOW BOLTS SUBMITTED

When the American Engineering Standards Committee's Sectional Committee on Bolt, Nut and Rivet Proportions that is sponsored by the American Society of Mechanical Engineers and the Society was organized, it was subdivided into several subcommittees, one of which was assigned the subject of agricultural bolts. Considerable time and work has been given to the gathering of data on current practice and bringing the manufacturers and users of this product together in the interest of standardization. At about the same time a similar program was inaugurated by the National Association of Farm Equipment Manufacturers, which represents very largely the farm implement manufacturers. The subcommittee of the Sectional Committee subsequently cooperated with the Committee of the National Association of Farm Equipment Manufacturers and has drafted a report to the Sectional Committee proposing four standardized bolts known as No. 3 Round Countersunk Short Square, No. 4 Square Head Countersunk, No. 6 Heavy Key Round-Head Countersunk and No. 7 Reverse Key Round-Head Countersunk. These were selected from among seven types that it was found were in most general use.

The Subcommittee's report has been issued to the members of the Sectional Committee for letter ballots and when approved will be submitted to the sponsors and to the American Engineering Standards Committee successively for final approval as tentative American Standard. Further information regarding the report may be obtained through the sponsor Societies.

[1] See THE JOURNAL, July, 1925, p. 34.

STANDARDS APPROVED BY LETTER-BALLOT

The Society letter-ballots covering the Division Reports approved at the 1925 Summer Meeting of the Society were returnable July 27, 1925. The letter vote is given in the following table; the first column of figures gives the number of members voting in favor of the reports; the second column, those voting against the report, and the third column, those who did not vote either way.

	Yes	*No*	*Not Voting*
AERONAUTIC DIVISION			
Aeronautical Safety-Code	228	1	77
Turnbuckles	227	0	79
Cable Shackles	227	0	79
Rigid Terminals	227	0	79
Brass Cotter-Pins	227	0	79
Cable Pulleys	227	0	79
Hose Liners	227	0	79
Cable Thimbles	227	0	79
Steel Washers for Wood	227	0	79
Marking of Pipe-Lines (Cancellation)	229	0	77
Gaging of Sheet Metal, Rods, Tubes, Wires and Cable (Cancellation)	229	0	77
Systems of Measurements (Cancellation)	229	0	77
AGRICULTURAL POWER-EQUIPMENT DIVISION			
Tractor Rating Code	228	0	78
Tractor Testing Forms	228	0	78
BALL AND ROLLER BEARINGS DIVISION			
Clutch-Release-Type Thrust Ball-Bearings (Cancellation)	246	0	60
ENGINE DIVISION			
Poppet Valves	248	4	54
Flywheel Housings	253	1	52
Carbureter Throttle-Levers	252	0	54
Piston-Pin Diameters	253	1	52
IRON AND STEEL DIVISION			
Molybdenum Steels	256	1	49
LIGHTING DIVISION			
Motorcoach Head-Lamp Mountings	239	0	67
MOTORBOAT DIVISION			
Engine Bed-Timbers	218	0	88
MOTORCOACH DIVISION			
Motorcoach Specifications	234	7	65
Motorcoach Nomenclature	233	6	67
PARTS AND FITTINGS DIVISION			
Compression-Type Tube-Fittings	251	0	55
STORAGE-BATTERY DIVISION			
Storage-Batteries	248	1	57

With reference to the negative votes, the following is quoted from the report to the Council of the Standards Tellers for 1925:

It will be noticed that the largest number of negative votes were cast against the reports on poppet valves and motorcoach specifications and nomenclature. Although the criticisms supporting these votes had been considered previously by the Engine and the Motorcoach Divisions, the Standards Department will send summaries of the criticisms to the Division members for further study at the next meetings.

ARMY-NAVY STANDARDS CONFERENCE

The second Army-Navy Air Service Conference that was held at Dayton, Ohio, July 20 to 24, resulted in the approval and acceptance of a considerable number of parts and materials specifications in addition to those accepted following the first conference that was held last year. The more recent parts specifications include castellated and plain nuts, aircraft bolts, cotter and flat-head pins, thimbles, shackles, pulleys, washers, streamline wires and terminals, eye bolts, hose liners, universal fittings and turnbuckles. Further consideration is to be given several items including standard lugs, hose clamps, engine controls, filler-caps, stick-control grips and engine-bearer spacings. The specifications for materials and tests for them include soft galvanized steel wire; extra flexible steel cable; high-strength steel wire; aluminum and aluminum alloys, sheets, rods, bars and tubes; naval brass bars and sheets; general specifications for metals and metal products; low-carbon cold-drawn or cold-rolled steel bars; and nickel, chrome-molybdenum and low-carbon steel seamless-tubes. Appendix A of the report of the Conference lists the types of pipe and tube fittings that are proposed as standard for Army and Navy use. A definite system of grouping the various types of parts and fittings and assigning blocks of specification numbers to them was also accepted.

At the time of the first Army-Navy Conference, the Aeronautic Division of the Standards Committee voted to approve the Army-Navy Standards for adoption by the Society to increase their use inasmuch as they were considered acceptable for industrial aircraft construction, although this branch of the industry is very limited at present. A number of the first Army-Navy Standards were submitted to and approved by the Standards Committee meeting last June, but were withheld from the new Handbook pages that will be issued at an early date because of changes made in the specification numbers at the Second Conference. As soon as copies of the approved specifications have been received by the Society, they will be referred to the Aeronautic Division of the Standards Committee for approval in accordance with regular procedure.

The representatives of the Aeronautic Division who attended the Conference in Dayton were H. A. Backus, of the Curtiss Aeroplane & Motor Corporation; Edward Wallace, of the Glenn L. Martin Co., and E. W. Rounds.

BODY NOMENCLATURE SURVEY

To determine the extent to which the industry has adopted the S.A.E. Standard Nomenclature for various types of open and closed bodies, the manufacturers of passenger-cars have been asked to inform the Society what names they use for the various types. It is expected that this survey will reopen the question as to the proper name for the five-passenger two-door type of body, generally called by car manufacturers "coach" or "brougham." The Passenger-Car Body Division has never specified a standard name for this type of body, on the basis that the standard nomenclature is intended to apply to the basic types of body and that variations of such basic types should include the basic name properly qualified. On this basis, the so-called coach or brougham should be called a "five-passenger coupé" or a "two-door sedan." Also, the impression has existed that the five-passenger two-door body, although probably the cheapest type of closed body to manufacture, would not endure owing to the inconvenience of this arrangement.

The results of the general survey will enable the Passenger-Car Body Division to make a further study of the standard nomenclature and to decide what changes, if any, are desirable.

BRITISH MOTOR ACCIDENTS AND INSURANCE

MOTOR-CAR insurance is a new branch of business. Twenty-five years ago it scarcely existed; 12 years ago it was still feeling its way by trial and error; today it is the largest earner of premiums among the miscellaneous newcomers to the insurance fold. Motor-car insurance premiums in the aggregate exceed those paid for workmen's compensation and are a very substantial factor in the annual accounts of many companies. The business has expanded so rapidly, especially since the war ended, that managers have been more concerned with putting and keeping the various categories of risks on a paying basis than with exerting material and economic pressure on motorists for the prevention of accidents. Yet something has been done, and if we may judge by the practice in older branches of insurance much more will be done.

A rebate of 10 per cent of the premium is given to a motor-car owner who makes no claim during the first year of insurance, and this rebate is repeated as a bonus for subsequent clean years. A motorist is allowed one accident in a year; if he should have the misfortune to incur two accidents in the same year, he may find it difficult to get a renewal of his policy. That penalty may in some cases be too severe, for the accidents may not have been the fault of the insured. Where accidents do not involve large claims—for third party damage, for example—the offices directly involved pay without determining the degree of culpability of their insured customer. This is called "knock for knock"; a collision always involves two cars and usually two insurance offices. The cost of investigating every accident would be prohibitive, so that losses rest where they fall unless the amounts involved are large. It seems to us that the 10 per cent rebate for a clean policy is scarcely generous enough, and that the penalty of refusing renewal may be too severe. We suggest for consideration: a progressive rebate for the second and subsequent clean years and for persistent claimants a progressive increase in premium rates. Seeing that the clean policies are no more than 40 per cent of the whole number in a year, a system of progressive rebates in premiums would need to be offset by progressive penalties on the errant 60 per cent who caused claims. In many of the United States the no-claim bonus is as much as 33⅓ per cent, but since the motor-car population is seven times as thick in the United States as it is here, the proportion of non-claim policies is probably lower.

It is the practice of some offices to maintain an inspection department that examines all second-hand commercial cars before they are accepted for insurance. By this means defects in brakes, steering-gear and bearings are discovered and put right before they reach the stage of causing accidents.—*Economist* (London).

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

LONG-DISTANCE TOURING

Need Seen for Investigations of Tire Wear and for Cars Designed for Camping

The discovery of America is usually credited to Christopher Columbus. It appears now from conversations with enthusiastic motorists that Columbus' enterprise is becoming a favorite sport. Thousands of motorists find much recreation and satisfaction in zigzagging the Country from east to west and from north to south, some of them in response to the fundamental desire for a primitive form of living.

Opinions have been expressed by many experts to the effect that long-distance touring in motor cars is now in its infancy. Upon elimination of a few obstacles, a trip West or South would no longer be an unusual event but a pastime in which anyone might indulge with much pleasure and without undue cost.

A few figures compiled by the Lincoln Highway Association show that good progress is being made in highway construction and maintenance. The Association states that, since 1913, $62,000,000 has been expended by States, counties and the Federal Government in shortening and relocating the Lincoln Highway, cutting down grades, widening curves, paving, eliminating railroad crossings and graveling long stretches along the Western plains. In a recently published article entitled What the Lincoln 'Way Has Cost' it is pointed out that the only States in which difficulty in traveling on the Lincoln Highway may be encountered are Ohio, Iowa, Nebraska and Utah. The nature of the road surface extending from New York City to San Francisco is also given and is repeated in Table 1.

TABLE 1—MILEAGE OF VARIOUS TYPES OF ROAD CONSTRUCTION ON LINCOLN HIGHWAY

Type of Road	Miles of Construction
Concrete	506.8
Brick	111.4
Asphalt	11.0
Macadam	449.3
Graded Gravel	1,204.4
Natural Gravel	187.5
Graded Earth	378.6
Natural Earth	74.6
Paved City-Streets	222.5

Aside from a large number of inducements, one feature of these extended Western trips will not appeal to those making them, the difficulty encountered by the majority if not by all motorists with the tires. So that nothing may obstruct the free development of the habit to travel by motor car, such annoyances should be carefully investigated.

It is well known that excessive tire-wear may be the result of many different causes, some of which are

(1) Condition of the road surface
(2) Construction and material of the tire
(3) The design and the condition of the steering linkage, the alignment of the wheels, the tractive force, the weight on the tires and the speed of the vehicle

INVESTIGATION OF TIRE-WEAR

The problem of tire-wear is not new. However, that it comes up after 25 years of progress in tire construction indicates that many cars are now being subjected to endurance tests that only a few years ago were considered extraordinary accomplishments. Moreover, it is doubtful if sufficient scientific investigations of tire-wear have been carried out, for the simple reason that they are expensive and require much time and effort. It is obvious that tests for any one quality in a tire are worthless when standing alone. The wear factors are so numerous and inter-related that, even where only one type, make and size of tire has been used in the tests, the variation in the individual characteristics is marked.

Because of the magnitude of the problem and its relation to the condition of the road surface, it is of interest to note that the University of Kansas is cooperating with the Bureau of Public Roads to determine through joint research the relative effect of various types of road surface on automobile tires. In a report entitled Investigation of Tire-Wear, by W. C. McNown, of the University of Kansas[2], are given five conclusions that have a direct bearing on the problem under consideration herein and for this reason they are reprinted here.

(1) The difference in the effects of certain high-type pavements, such as concrete and brick, and probably asphalt, upon tire-wear is not great if these pavements are in high-class surface condition
(2) Roughness of longitudinal contour causing bounding, acceleration, impact and deceleration, with accompanying slippage, has a marked effect upon the wear of tires running under "standard" inflation
(3) Under-inflation is probably the cause of much greater wear than is ordinarily assigned to it, although it cannot be said how much this effect is offset by decreased wear due to the lessened amount of bounding and impact
(4) A vast amount of tire-wear results from various causes not assignable to pavement type. And, if a great amount of value in tires is dissipated in other ways than in running, properly controlled, over well-made surfaces, care should be taken not to over-estimate this value in the solution of problems in highway economics until more data are available
(5) Tire-wear investigations, using laboratory methods and small-scale devices instead of standard equipment, may give results that are wholly misleading. Relative values may be obtained but they should be used with caution until more is known about the relation between the amount of value actually existing in tires and that used in ways other than running properly over first-class pavements, as by stopping and starting, by physical deterioration while standing, by running over rough pavements and by abuses such as under-inflation and high speeds

BALLOON TIRES AND SEVERE SERVICE

With regard to the relation between tire-wear and the construction of the tire, it is doubtful whether balloon tires can be considered a step in advance. The balloon tire's outstanding characteristic is pliancy and ability to "absorb" small obstructions. However, the resistance to wear and blow-outs of this type of tire leaves much to be desired in continuous severe service. The severe deformations so frequently encountered militate against durability. Moreover, in long-

[1] See *Motor Travel*, April, 1925, p. 24.

[2] See Proceedings of the Fourth Annual Meeting of the Highway Research Board, p. 22.

distance touring not enough attention is given to the maintenance of proper inflation-pressure, the interchanging of wheels and the repairing of minor cuts. These facts accentuate the various weaknesses of the balloon tires. Tire designers are further put to the test in endeavoring to overcome uneven balloon-tire tread-wear.

Moreover, shimmying of the tires and the consequent motion throughout the steering linkage, while much discussed, has not yet been satisfactorily eliminated. The effort required to steer a car and the reactions resulting in the steering linkage from shocks originating between the tire and the road are of such magnitude that relatively rapid wear and slackness inevitably result from them. The most popular method of making a steering column work easily is to reduce the contact area in the reduction-gears to the minimum. Because of this small contact area, a slackness will develop in hard service in less than 5000 miles. Then, because of the lack of stability of large-size under-inflated tires, a synchronism of tire yield and give in the steering mechanism, due to slackness, develops beyond control, giving the driver the feeling of being unable to hold the car on the road. For this reason, it seems most desirable that an automatic adjustment for the steering-gear should be developed. A further study of such problems should prove of great benefit.

From the standpoint of wear, rear tires are as great offenders as front tires. Due to the great advantages incident to fitting all four wheels with the same size of tire, the uneven weight-distribution between the front and the rear axles frequently is overlooked. Accordingly, a distinct tendency to overload the rear tires exists. In addition, gear-ratios and engine performance are increased in an effort to obtain greater tractive effort. All these burdens have to be carried by the rear tires. Therefore, to make long-distance touring even more popular, a study of these factors, to be carried out jointly by car and tire manufacturers, should be instituted.

Camping Equipment and Motor Cars

Touring across the continent has become so extensive that special bodies should be designed with the purpose of facilitating camping. About 25 years ago a few alert minds visualized the need for individual transportation. Having this, a need now exists for an automobile that is suitable not only for transportation but for sleeping quarters as well. Nearly everyone cherishes the hope of some day escaping the confining environments of modern city life to spend a few weeks in camping and exploring and in many ways living in the romantic manner of his ancestors. Two and a half billion dollars, according to various estimates, will be spent this year by motor campers and automobile tourists. This represents outlay for gas, oil, repairs, replacements, food, hotel accommodations, souvenirs and other things incident to motor travel. In 1924, according to authorities, some 12,000,000 persons used motor camping-equipment and slept in their own tents or cars at night. In 1925 the number will be greater. The daily expense per person is figured at $2. In view of these staggering facts, provisions in the design of the automobile for sleeping should receive a new impetus. The suggestion is made that body designers obtain some first-hand information by taking transcontinental trips in person, with such camping equipment as is frequently seen packed on all classes of car. Designers should bear in mind the fact that, while the public desires cars designed for camping purposes, these cars should not be harder to operate or less roomy than conventional cars but should be suitable in every respect for long-distance touring. The amount of baggage necessary for long trips is usually great, so that the space within the car, as well as that on various projecting parts is at a premium. Trailers cannot meet the needs because of certain well-known limiting conditions that are involved in their use.

Various playground and recreation associations are now providing in carefully selected places and in parks, tents or other primitive structures for sleeping quarters, together with the most important sanitary facilities.

However, aside from this, there are still 12,000,000 people who have enjoyed motor camping in 1924; and in 1925 most likely the same number, if not a greater one, will continue to follow the ancient heritage of living in a place that they can call their own. In view of this demand and of the great sum of money expended for camping equipment, it is urged that serious thought be given to the problem of designing cars so that various parts shall serve a double purpose, namely, as motor-vehicle elements and as units of shelter or sleeping accommodations.

ROLLING-RESISTANCE OF MOTOR VEHICLES

Tractive Ability Calculated and Empirical Rolling Resistance Values Given

Inquiries are frequently received by the Society's Research Department pertaining to the power required of motor vehicles to negotiate various roads and gradients. In replying it is realized that if the information is desired for motorbuses the data given must be especially reliable because these vehicles are required to travel daily over a definite route on relatively fast schedule time. The maximum gradients of the route are usually known. Frequently it happens that if these grades are long the ability to negotiate them in high or third gear instead of the next lower gear is the deciding factor in the selection of a make of motorbus. The calculations given herewith are, however, not only applicable to motorbuses but may be used for trucks and passenger cars as well.

The maximum torque of the engine must be known. If that cannot be obtained from the builder, it can be calculated with fair accuracy from the formula

$$T = 5.66\ d^2sn$$

where

d = Bore of engine in inches
n = Number of cylinders
s = Stroke of engine in inches
T = Maximum torque of engine in pound-inches

If we further represent by R the total speed-reduction ratio between the engine and the driving wheels, and if e_m denotes the efficiency of the driving mechanism, the torque T_1 transmitted to the driving wheels is obviously $T_1 = TRe_m$. The mechanical efficiency e_m of the mechanism may be taken as 0.90 for high gear and from 0.75 to 0.85 for low and intermediate gears.

If the torque of the driving wheels is divided by their radius, 1/2 D, given in inches, we obtain the total tractive force F in pounds, namely,

$$F = 2\ TRe_m/D \qquad (1)$$

This tractive force is available to overcome the road-resistance, the wind-resistance and the resistance due to gradients or acceleration. Some very reliable tests on rolling and air-resistance are reported in the Report of Committee on the Economic Theory of Highway Improvement, by T. R. Agg, chairman of the committee.[3] The results are of considerable interest inasmuch as they were obtained in tests carried out on the most representative types of road. Moreover, the data obtained for paved surfaces are in fair accord with the rolling-resistance results secured by Prof. E. H. Lockwood on dynamometer drums made of metal-shrouded paper cylinders. Professor Lockwood's finding on the rolling-resistance of motor trucks with solid tires, of 40 lb. per ton, on rollers is given to supplement Professor Agg's report that is reprinted in part below.

> Rolling plus air-resistance for self-propelled types of vehicle is affected by the following factors:
> (1) The smoothness of the road surface
> (2) The degree of rigidity of the road surface
> (3) The type of tire
> (4) The temperature of the tire and of the road surface if of bituminous type
> (5) The exact texture of the road surface

[3] See Proceedings of the Fourth Annual Meeting of the Highway Research Board, p. 15.

TABLE 2—AVERAGE VALUES IN POUNDS PER TON FOR ROLLING PLUS AIR-RESISTANCE FOR DIFFERENT CLASSES OF VEHICLE ON VARIOUS ROAD-SURFACES

	Motorbuses and Passenger Cars[4]	Motor Trucks[5]
Best Paved Surfaces	37	22
Paved Surfaces in Average Condition	42	30
Best Water-Bound Gravel	55	40
Ordinary Gravel	65	50
Fair to Good Earth-Roads	75	60
Best Earth-Roads	65	50

[4] Speed 35 m.p.h.; high-pressure cord tires. For low-pressure cord tires add 10 lb. per ton to figures given.
[5] Speed 15 m.p.h.; pneumatic tires.

(6) The gross weight carried by the tires
(7) That size of tire seems to affect rolling-resistance very little so long as the tires conform to good practice as to size and to load
(8) That low-pressure cord tires have somewhat higher rolling-resistance than the high-pressure cords, but the difference decreases for the rougher surfaces
(9) That average values for rolling plus air-resistance for the several classes of vehicle under year-round operating conditions appear to be as given in Table 2.

The investigations of the relation between rolling-resistance and fuel consumption show that the higher the resistance the greater the fuel consumption; but the relation is by no means a simple one. Type of vehicle, speeds and the personal equation of the driver all enter into the problem.

Knowing the rolling-resistance and air-resistance and the resistance due to gradients, we may amplify equation (1) to read

$$2\ TRe_m/D = GA/100 + Gf/2000$$

where
A = Gradient in per cent
D = Diameter of driving wheels in inches
e_m = Mechanical efficiency of driving mechanism expressed decimally
f = Rolling plus air-resistance in pounds per ton
G = Gross weight of vehicle in pounds
R = Total speed-reduction ratio between the engine and the driving wheels
T = Maximum torque of engine in pound-inches

The above equation can be simplified to read

$$4000\ TRe_m/D = G\ (20A + f) \qquad (2)$$

For the substitution of numerical values, we shall choose the following for a motorbus: $D = 36$, $f = 55$, $G = 14{,}000$, $R = 6$ and $T = 3000$. With this information, we can proceed to determine the maximum gradient that the vehicle will negotiate in high gear. It is

$$4000 \times 3000 \times 6 \times 0.9/36 = 14{,}000\ (20A + 55) \qquad (22)$$

From this it follows that

$$20A = 74$$

hence

$$A = 3.7 \text{ per cent}$$

Having determined that the motorbus will on best water-bound gravel negotiate a 3.7-per cent gradient, we can also estimate what its maximum acceleration, a, will be. It is

$$a/32.16 = A/100$$

hence

$$a = 3.70\ (32.16/100)$$
$$= 1.20 \text{ ft. per sec. per sec.}$$

Therefore the motorbus under consideration will accelerate from 10 to 30 m.p.h. in $20(1.46/1.20) = 24.40$ sec.

From Equation (2) we may of course also determine in a similar way the permissible gross-weight or the required ratio if the gradient and other factors are known. The application of Equations (1) and (2) to motor trucks and passenger cars is analogous to the cases given above and need not be repeated here.

MEETINGS OF THE SOCIETY

(*Concluded from p. 224*)

would follow since the hydroplane is superior from the standpoints of increased speed in racing craft and safety in cruisers.

Answering the objection raised against the hydroplane that the steps dragged the water, this was admitted to be true if the steps extended the full length of the hydroplane. Reducing the depth and the length of the steps would eliminate the drag at high speed and at slow speed drag would occur irrespective of whether the design included steps or not.

Metal hulls will find an increasing use for high-speed boats, the principal reasons being the elimination of the bailing that is now necessary with wooden hulls and the saving in weight following the overcoming of the waterlogging of hulls, which is estimated at 500 lb. in some instances. While wood is weak in a sidewise direction, metal has a high tensile-strength in both directions, which is also an advantage. Although the use of metal in hull construction would increase the cost, this added expense is justified in view of the better properties of the material.

With reference to placing limitations on engine and hull construction, Mr. Fauber considered the regulation of engine displacement satisfactory but thought that too many regulations would handicap the development of the motorboat industry. He believed that the length and the minimum width of boats should be limited also. In the case of the high-speed boat, other limitations would be detrimental to the industry; he thought, however, that more restrictions could be imposed upon the designers of cruisers, especially on account of the additional safety precautions.

Hydroplanes Speedier and Safer

That a hydroplane was 15 m.p.h. faster than a displacement boat for the same engine speed was brought out by Gerald T. White, editor of *The Rudder*, who cited a Mississippi Valley regatta, in which a hydroplane made 60 m.p.h., as compared with 45 m.p.h. for the displacement type of motorboat. The two craft were each 22 ft. in length, and the hydroplane was slightly wider than the motorboat. The powerplants were identical and operated at the same speed, 2200 r.p.m.

The hydroplane was the safer craft in his opinion, this being based upon the mishaps that occurred at a powerboat regatta in which 28 craft were entered. Of this number 5 were displacement boats powered with 220-hp. Hispano-Suiza engines, the remainder being hydroplanes. Two of the former turned over during the races, while the only accident sustaind by the hydroplanes was one broken rudder, which caused the craft to go "joy riding" with somewhat amusing, but by no means serious, results.

Chairman Carlson again emphasized the interest in, and the need for, standardization in the motorboat industry and urged that the National Association of Engine & Boat Manufacturers send their representatives to meetings of the Society and that they cooperate with our Standards Committee.

An expression of thanks was extended to the Hotel Commodore for donating the use of the East Ballroom and other facilities for the meeting.

Development Difficulties and the Design of Hydraulic-Brake Units

By H. E. Maynard[1]

Semi-Annual Meeting Paper *Illustrated with* Drawings

ABSTRACT

THE principles of hydraulics have long been known and the use of a liquid for transmitting power has proved safe and reliable in many applications, notably in the operation of passenger elevators, hence it was natural to make use of these principles in a device for controlling an automobile under traffic conditions that demand an efficient and dependable braking mechanism. The ideal of equalized braking-effort is sought but variation in the coefficient of friction between brake bands and brake-drums and between tires and road introduces complications, so we must be content for the present with the nearest possible approach to equalized pressure at the brake bands. In the hydraulic system, pressure is transmitted equally throughout the liquid and to the levers that actuate the brake bands. These levers are also designed to transmit the pressure equally to the brake bands on all four wheels.

The author describes briefly the general construction of the system but dwells more particularly upon the development of the major elements and the difficulties overcome in the search for entirely satisfactory materials. A slip-joint connection between the brake-pedal lever and the piston in the master cylinder was adopted to avoid drawing air into the system and producing soft pedal-action due to compressibility of the air. For the same reason a positive hand-operated plunger-pump with a needle valve is used for refilling the master cylinder from the supply reservoir. It was necessary to develop a flexible hose connection from the rigid tubes on the frame to the wheel cylinders that would be non-collapsible and also non-expansible under internal pressure, and the solution of the problem is described.

Prolonged search for a material that would resist temperatures of more than 200 deg. fahr. and that would otherwise be suitable for use in the cups that provide the seal for the pistons in their cylinders finally resulted in the adoption of a special rubber composition. The liquid used in the system must remain fluid at temperatures well below zero, must not corrode the copper tubes or the cast-iron cylinders, must not attack the rubber cups and hose nor become gummy. That now used with satisfaction is a solution of 50 per cent castor oil and 50 per cent alcohol, neutralized with potassium hydroxide.

In a four-wheel-brake system, equalized pressure applied to all wheels is believed to give the maximum safe braking-effort. When the brakes are applied the center of gravity of the car's mass moves forward and often as much as 50 per cent of the weight is transferred to the front wheels, consequently equal braking-effort on the front and rear wheels assists in stopping all wheels at the same time, yet the likelihood of locking the front wheels is slight. In simultaneously making a turn and braking, with equalized pressure, the shifting of the center of gravity toward the front and toward the outside of the turn results in locking the inside rear-wheel first, then in succession the outside rear-wheel, the inside front-wheel and finally the outside front-wheel, thus automatically giving maximum braking-effort on the turn as well as on the straightaway.

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IN presenting a paper on hydraulic brakes, it is not my intention to dwell on the description of devices used nor to deal with facts relating to performance. A far more interesting phase and one of value is the development of the various units and some of the difficulties overcome in bringing the hydraulic-brake system to its present state of perfection.

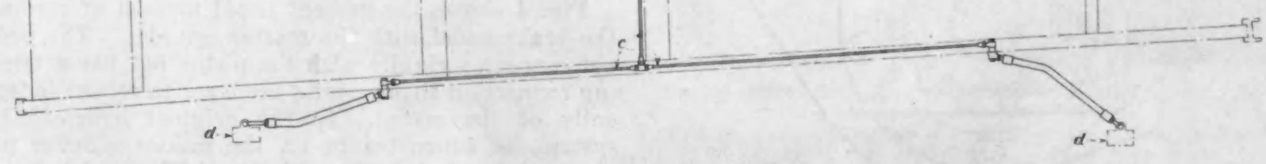

Fig. 1—General Arrangement of Four-Wheel Hydraulic-Brake System

The Piston of the Master Cylinder *a* Is Connected by a Slip-Joint at *b* with the Pedal Lever. Copper Tubes *c* Transmit Pressure Through Liquid to the Wheel Cylinders *d*. The Wheel Cylinders Are Connected by Flexible Hose with the Rigid Copper Tubes on the Car Frame. Pistons in the Wheel Cylinders Actuate Levers That Operate the Brake Bands Which Are Not Shown

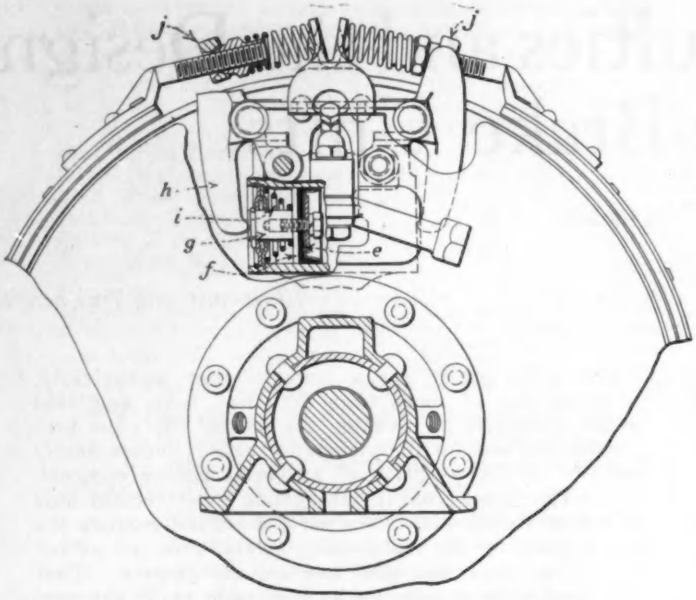

FIG. 2—DESIGN OF ENCLOSED WHEEL-CYLINDER

The Cylinder and Brake-Operating Mechanism Are Located within the Brake Drum and Covered by a Dust Shield. A Rubber Cup *e* Is Attached to the Piston *f* by a Screw and Prevents Seepage of the Liquid past the Piston. An Extension of the Piston Passes through the Brass Guide *g* and Presses Against *h* That Operates the Brake Band. The Spring *i* Returns the Piston to Its Normal Position. Adjustment of the Brake Band Is Effected by Turning Nuts *j*

The fundamental principles of hydraulics are far from being new to knowledge. The use of liquid as a medium for transmitting power has found many applications and in every instance where safety and reliability are vital it has proved its value. The hydraulic elevator is, perhaps, the most outstanding example of an hydraulic device that is working day after day and meeting the demand for the utmost reliability to safeguard the lives of the many thousands who use it. Is it not natural, then, for us to consider the use of this principle in a device for controlling an automobile in these days of congested traffic when the demand for safety calls for a braking mechanism that is not only efficient but that can be depended upon?

It is admitted by all, I believe, that the satisfactory

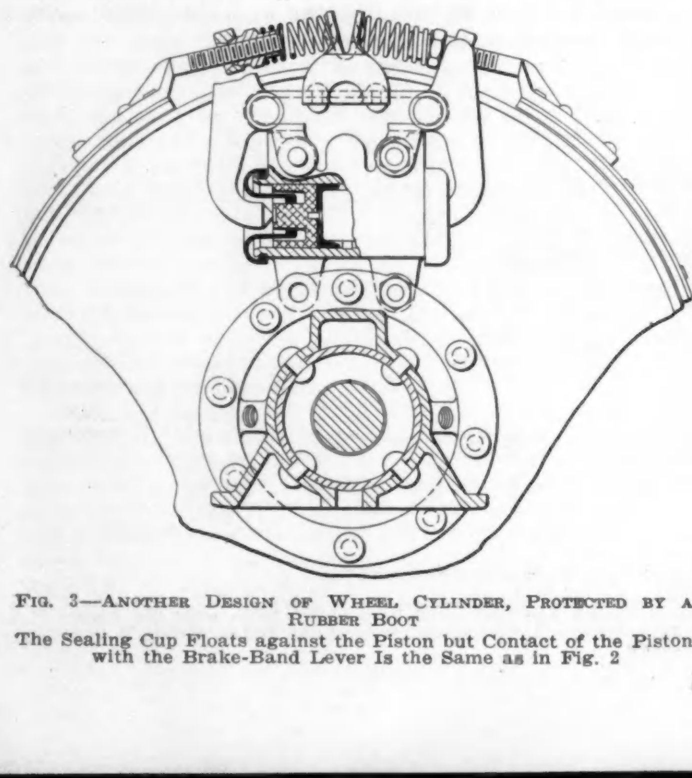

FIG. 3—ANOTHER DESIGN OF WHEEL CYLINDER, PROTECTED BY A RUBBER BOOT

The Sealing Cup Floats against the Piston but Contact of the Piston with the Brake-Band Lever Is the Same as in Fig. 2

performance of brakes, whether applied on two or all four wheels of a car, requires equalized pressure to the brake bands at least. Equalized braking-effort, the ideal to be sought, is what we attempt to attain, of course, but variation in the coefficient of friction between the brake-lining and the brake-drums and also between the tires and the road complicates the problem to such an extent that, for the present, at least, we content ourselves with pressure at the brake bands that is as nearly equalized as possible.

In the attempt to apply this pressure by mechanical means, the use of pull rods, levers, equalizing devices and universal-joints introduces variations in friction, unequal angles of levers and losses in efficiency that may become decisive factors in applying more pressure to one brake band than to the others. It is not during light applications of pressure that this inequality is noticeable, but the effect is very apparent during an emergency stop or when retarding the car from high speed. In the hydraulic application, the movement of the master-cylinder piston, caused by depressing the brake pedal, transfers perfectly equalized pressure to the pistons in all four wheel-cylinders and thence through short levers to the brake bands.

MAJOR ELEMENTS OF THE SYSTEM

The hydraulic-brake system is shown diagrammatically in Fig. 1. The master cylinder *a* is connected at *b* with the brake pedal, which is not indicated. Distributing tubes *c* convey the liquid from the master cylinder to the wheel cylinders *d*, the pistons of which operate levers connected directly with the ends of the brake bands, which also are not shown. Pressure on these levers draws the brake bands into contact with the brake-drums and retards or stops the car.

The wheel-cylinder construction is shown in detail in Fig. 2. The sealing cup *e* is attached to the piston *f*, and an extension of the latter passes through the brass guide *g* to make contact with the brake-band actuating lever *h*. In this design, a return spring *i* is inserted between the guide and the piston to ensure the quick return of the piston to its normal position. Brake-band adjustment for wear is made by turning the adjusting nuts *j* that ride in ball sockets in the levers. Springs between the levers and a central support free the bands from the drums and also assist in returning the pistons and forcing the liquid in the wheel cylinder back toward the master cylinder. The entire wheel-cylinder is mounted inside the brake-drum and is protected effectively by the enclosing dust shield. In many installations the wheel cylinders are attached directly to the axle parts and are not protected by dust shields.

Another design, in which the wheel cylinder and its parts are protected by a rubber boot, is shown in Fig. 3. In this design the sealing cup is not attached to the piston but is allowed to float against it. The contact with the brake-band levers is the same as in Fig. 2.

SLIDING CONNECTION WITH BRAKE-PEDAL LEVER

Fig. 4 shows the present usual method of connecting the brake pedal with the master cylinder. The pedal is not connected rigidly with the piston but has a telescoping connection that permits the lever to return independently of the piston. In the original hydraulic-brake system, as submitted to us, the master-cylinder piston was connected directly with the brake pedal and was forced to return to its original position by the pull of a spring on the pedal. In the original construction, also, two small holes leading to the reserve-fluid supply-tank

were located at a point about ⅛ in. from the inner edge of the piston cup. The object was to provide an automatic means for supplying brake fluid to the system whenever any fluid was lost by leakage or otherwise.

Considerable road work was done with this early type of braking system on many makes of car and it was found that, while some operated very satisfactorily over a period of months, others would give difficulty after a short time. Careful analysis showed that the system was fundamentally and inherently wrong; it was impossible to keep the system filled with fluid without danger of drawing in air, and this is what would happen because, whenever a slight quantity of fluid was lost, the spring, when pulling the master piston to its normal position, momentarily created a vacuum in the line. As the total quantity of liquid in the system was very small, a very small volume of air so drawn in immediately caused soft pedal-action because of the compressibility of the air.

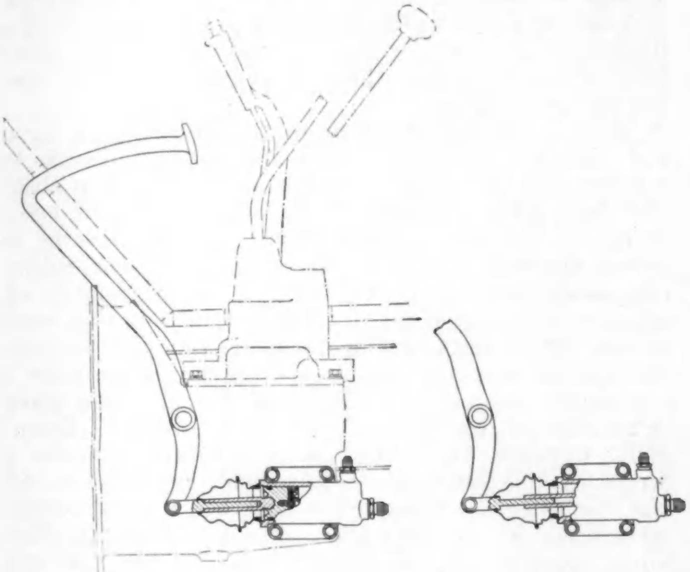

FIG. 4—SLIDING CONNECTION BETWEEN PEDAL LEVER AND MASTER-CYLINDER PISTON

The Main Drawing Shows the Connection in Brake-Operating Position while That at the Right Shows the Lever Retracted. This Construction Relieves the Piston of the Return Pull of the Pedal Spring and Avoids the Creation of a Vacuum in the Cylinder and Resultant Drawing-In of Air. Air in the System Would Cause Soft Pedal-Action Due to Compressibility of the Air

Hence it was decided to discard the automatic means of refilling the master cylinder and to adopt a sliding connection between the master piston and the brake pedal, as shown, and to develop means of supplying liquid from the supply tank by a pump and valve, as illustrated in Fig. 5.

The supply tank is provided with a combined needle valve and pumping plunger. By unscrewing the valve and depressing the handle in opposition to the return spring, liquid is forced into the system, thus easily refilling the master cylinder. In effect, this is like making an adjustment by a turnbuckle, which is done commonly in the mechanical-brake system. This pump is used effectively for refilling the hydraulic system or for "bleeding" the air when priming it initially. When the system is filled, the valve is screwed back into place, sealing the system from the supply tank.

Development of the Flexible Leads

For transmitting pressure from the master cylinder through tubes to the wheel cylinders it is necessary to

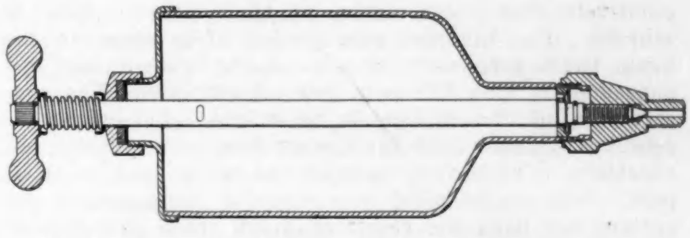

FIG. 5—SUPPLY RESERVOIR AND COMBINED NEEDLE VALVE AND PLUNGER PUMP

Losses of Liquid from the System Are Replaced by Positive Hand Operation. The Needle Valve Is Unscrewed by the Hand Wheel and the Plunger Is Pushed Down, Forcing Liquid through the Valve. The Needle Is Then Screwed Down, Sealing the Reservoir against Return of the Liquid under Pressure in the System

have flexible connections from the rigid tubes on the frame to the rear wheels to allow for the action of the vehicle springs and to the front wheels for the same purpose and also to allow for the turning of the front wheels in guiding the car. The development of a suitable hose for this purpose presented some interesting and difficult problems. Not only must the hose allow for free movements, but it must not fail under extreme flexion repeated hundreds of thousands of times, nor must it flex so sharply at any place as to cause it to collapse and interfere with the free flow of the liquid used for transmitting the pressure.

These requirements were comparatively easy to meet but of more vital importance was the need of a non-expanding hose in which the volume of liquid in a given length would not increase materially as pressure was applied. The ratio of pedal travel to brake-band travel is high, because the total volume of liquid in the system is small, hence, to obtain maximum efficiency in the system, it is necessary to avoid any increase in the volumetric capacity of the hose due to expansion. The hose now in use in practically all of the hydraulic-brake installations is shown in Fig. 6. It consists of an inner tube of rubber surrounded by four or five plies of fabric with an outer rubber covering, the whole being vulcanized to form a tough pliable hose. But, as a hose or rubber and fabric alone would expand considerably under internal pressure, a close-wound steel spring is inserted. The hose has an internal diameter of ¼ in. and the outside diameter of the spring is 5/16 in., hence to insert the spring, the tube must be expanded. The spring then holds the walls of the hose in tension so that they resist further expansion under operating pressure.

The end connections are then placed over the tube ends, copper nipples being forced between the steel spring and the hose, thus forcing the outer rubber covering into internal annular grooves in the cap, making the whole assembly a non-expanding and liquid-tight unit.

System Perfected by Careful Study

The hydraulic brake in use today on many thousands of cars has proved effective and reliable. The system is

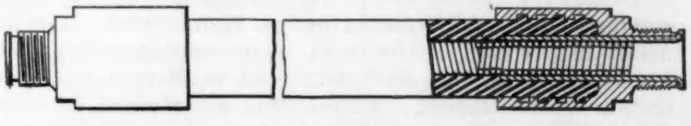

FIG. 6—FLEXIBLE HOSE CONNECTION FROM TUBING ON THE FRAME TO WHEEL CYLINDERS

This Is Made of Rubber and Four or Five Plies of Fabric Vulcanized Together and Lined with Close-Wound Steel Wire. The Coiled Wire Has an Outer Diameter $\frac{1}{16}$ In. Larger than the Inside Diameter of the Hose and Expands the Hose So That Its Volumetric Capacity Will Not Increase under Internal Pressure from the Liquid. A Copper Nipple, at the Right, Is Forced between the Wire and the Hose, Expanding the Rubber Covering into the Annular Grooves inside the End Connection

positively free from rattle, as there are no rods to vibrate. The inherent equalization of pressure to the brake bands gives uniform wear on the brake-linings and consequently long life with few adjustments. The construction of the system to meet the requirements is peculiarly simple and the design has been worked out carefully. The development of the design and of those parts that are so vital to successful operation of the system has been the result of much study and experimentation. An account of some of the work that has been done and of the troubles experienced in the early stages of its development will show clearly why the hydraulic system occupies the place it does today in the automobile industry.

In the original study of the system two outstanding uncertainties appeared to us to require utmost attention. The first was the possibility of leakage and its effect; the second was the hazard due to temperature changes under both normal and abnormal operating-conditions. It was realized that, if we could avoid these two dangers satisfactorily and in a practical way, the system must be a success.

How the Piston Cup Was Developed

In the early experimental installations the cups for sealing the master cylinder and the wheel cylinders were made of rawhide formed in a die and held in place on the pistons by a screw. As the rawhide had little or no ability to press against the walls of the cylinders, a phosphor-bronze expander was inserted in the cup to supply the necessary pressure to maintain a static seal. Otherwise, in almost all respects, rawhide seemed an ideal material for sealing the system. It was pliable, impervious to liquids and capable of maintaining a perfect seal under pressures up to and above 1000 lb. per sq. in., or much in excess of any possible requirement in service. Furthermore, the natural oils in the skin aided materially in lubricating the cylinder-walls and reducing friction to the minimum when applying pressure to operate the brakes. One important quality, however, nature had not supplied, that is, the ability to withstand high temperature. In ordinary use of the brakes, or even on fairly long descents with intermittent application of the brakes, the temperature of the brake cylinders and rawhide cups would not exceed 150 deg. fahr. and no damage was apparent. In the original applications, a number of which are still in constant use, the wheel cylinders are exposed to the air currents and do not become heated to the temperature of the cylinders that are now protected by enclosing dust shields. Careful consideration of what might happen in the operation of the braking system raised two questions; (*a*) What would happen to rawhide cups when subjected to the oven temperature required for drying chassis paints in the factory production of cars? and (*b*) What maximum temperature would be developed in the cylinders under the most extreme operating-conditions on descending grades?

To find the answer to the first question, cylinders with rawhide cups were passed through factory ovens and in about 10 per cent of the tests, if the exposure exceeded a certain time, the rawhide would be damaged. The answer to the second question was ascertained in this way: To reproduce in Detroit what we considered the equivalent of a severe grade condition, we selected the hottest day available, put one of our experimental cars into second gear, applied the full engine power and held the speed down to 20 m.p.h. by application of the brakes. The run was continued until a failure of the brake system resulted, which occurred when a cylinder temperature of 220 deg. fahr. was reached. A distance of 17 miles was traversed before the failure occurred. Examination into the cause of failure under this test showed that considerable damage had been done to the rawhide by the heat. The fatty content of the rawhide was driven out of the cups, leaving a shriveled mass of fibrous material that is the basic structure that gives rawhide its strength and flexibility.

Rubber Finally Solves the Problem

As rawhide had so nearly met our requirements, it was natural that in a further search for a suitable material we should investigate the possibilities of the use of leather for the cups. Manufacturers of leather products were consulted and their ingenuity was drawn upon to produce a leather cup that would withstand the expected temperatures and retain the desirable properties of rawhide. Their efforts were unavailing, however, as, in the process of tanning, the oil cells that make rawhide impervious to liquid under high pressure had been broken down and porosity resulted. Cups made from many kinds of leather were submitted and tried but none met the requirements.

Next we considered the properties of rubber, a material that is hermetically sealed and non-compressible to a degree and that is vulcanized at a temperature of about 250 deg. This seemed to fit in ideally with our needs except in the matter of friction. In the endeavor to reduce the wall friction to the minimum, some rubber compounds were made in which a large quantity of graphite was incorporated. The results obtained were satisfactory from the standpoint of friction but the material did not have the resilience necessary to maintain a seal against the cylinder-walls, and the cup edges flaked or chipped off, causing failures due to leakage. Eventually, however, the rubber manufacturers produced a compound that meets the requirements in every respect and that is in use today. The cups we now use form a perfect seal at all times and continue to function after being subjected to the highest temperatures that are employed in drying the paint in the process of car production or that are generated in the brake cylinders by use of the car on the road. Moreover, the material has the toughness and resistance to wear that give it long life.

Long Search for a Suitable Liquid

Hand in hand with the other problems of bringing the hydraulic brake to a state of perfection, the kind of liquid to use in the system was given much thought. In the experimental installations, particularly those having rawhide piston-seals, a solution of 50 per cent glycerin and 50 per cent alcohol was used. This flowed freely at all temperatures, had sufficient viscosity to form a good seal and kept the rawhide cups in a soft pliable condition. Glycerin, however, is hygroscopic; it absorbs moisture from the air and the moisture soon formed a rusty coating on the inside of the cast-iron cylinders. The rust caused a slight seepage past the pistons. Also, the alcohol evaporated gradually and the solution became gummy and in time retarded the free return of the pistons. The injurious action of the liquid on the cylinders was so slow that the solution might have been considered satisfactory but, in filling the system and removing the air from the lines, great care had to be taken to prevent the glycerin from coming into contact with the brake-linings, as it was impossible to wipe or even wash it off. When it dried, it caused the lining to become sticky and resulted in erratic action when the brakes

were applied. So much care had to be used in handling the liquid that we did not feel it would be satisfactory for general use.

Neutralized Castor Oil and Alcohol Adopted

Mineral oils were out of the question, because of their softening effect on rubber, which would render that material unfit for use in the cups and hose. Of the liquids available that would have no detrimental effect on rubber and that would function properly through wide variations of temperature, glycerin and castor oil were the only ones that seemed to possess possibilities, and, as the former was considered unsuitable for the reasons given, castor oil was adopted.

Castor oil is used by rubber manufacturers in some applications as a preservative of rubber, it has decided lubricating value and does not deteriorate with use in the hydraulic braking-system. Its high viscosity at low temperatures made it unsuitable for use by itself but, when combined with alcohol in equal parts, it maintains a free-flowing condition at temperatures well below zero. The oil, when chemically pure and when mixed with chemically pure alcohol, also protects metallic surfaces from corrosion. Commercial castor oil and denatured alcohol of commercial quality have an effect on the system which, while showing no immediate harmful results, forms a scale and a sludge that it was thought best to avoid. The accumulation of scale and sludge is due to chemical action that can be traced to two causes, (*a*) the acid-content of commercial denatured alcohol in conjunction with commercial grades of castor oil, which acts upon the metal parts of the system and (*b*) the sulphur-content of the rubber hose and cups.

The free-acid content in the alcohol and oil was found to be a very important factor in causing corrosion. Copper tubing exposed for long periods to pure medicinal castor oil and pure 95 per cent ethyl alcohol showed no corrosion or chemical action whatever, but tubing exposed to a 50-50 mixture of the commercial grades showed decided action within a few days. The solution turned green, indicating the formation of soluble salts of copper and the surface of the metal became black. Similar action occurred when polished steel rods were exposed to the commercial brake-solution, rust soon began to form and the solution turned dark brown, proving the presence of soluble iron salts.

The use of chemically pure solutions is not practical on account of the high cost, hence it was necessary to find some means of preventing or controlling the corrosion. A series of corrosion tests carried on in the laboratory over a long period proved that the corrosion resulting from the acid-content of the commercial solution could be prevented by the neutralization of the acids before introducing the liquid into the brake system. Potassium hydroxide is used for this purpose, in quantities slightly in excess of the theoretical requirement, to insure that no free acid can remain in the system.

A high percentage of sulphur-content in rubber causes rapid corrosion of the copper parts of the system, with resultant flakes of copper sulphide scale which disintegrate gradually and form sludge. The brake solution in contact with rubber appears to act as a carrier, extracting the sulphur from the rubber and corroding all copper parts with which it comes into contact. This form of chemical action is not serious. While it is practically impossible to make a satisfactory rubber compound without a certain percentage of free sulphur, the amount in either the cups or the hose now in use is so small that the corrosion, although visible upon examination, cannot be carried to a point where it has any detrimental effect in the system.

Seamless copper tubing gives entire satisfaction for retaining the liquid in its path from the master cylinder to the hose. It lends itself to the bending necessary when assembling the lines and its ductility allows it to be safely flared at the ends for the fittings. In making the connections to the various fittings used in the system, the S.A.E. Standard flared union, somewhat modified, has been found to give the best results. The modification consists in a closer fit between the nut and the tubing and chamfering the union on a slight radius at the place where the taper of the nut meets the enclosure for the tube itself. Tests of many types of fitting were made to determine the one best suited for the purpose but, because of the high pressures used and the possible slight but rapid vibration of the tubes in the frame, the S.A.E. Standard type proved best. I feel safe in saying that, once the lines are installed and tested, the fear of leaks or breakages can be forgotten.

Equalized Pressure Gives Maximum Safe Braking-Effect

In connection with four-wheel braking, much discussion has been had as to whether uniform braking-effort should be used on all wheels or the front or rear wheels should carry most of the braking load. In the hydraulic system equal pressure must be applied to all four wheel-cylinders and it is the universal practice to carry the pressure through the levers so as to apply equal pressure to all four brake-bands. We feel that, by so arranging these pressures, we are giving the public the maximum braking-effort that can be used with safety. It is generally agreed that locking the front-wheels of a car when applying the brakes is undesirable. This raises the question that is often asked, Why do we not apply more braking effort to the rear wheels than to the front wheels? The answer is, when retarding the speed of the car the center of gravity of the car's mass moves forward to such an extent that often as much as 50 per cent of the weight is transferred to the front wheels. This means that to stop all four wheels at the same time the same additional proportion of braking effort must be applied to the front wheels. It is obvious, therefore, that with an equal braking-effort on all four wheels, the chance of locking the front wheels and putting the steering out of the control of the driver is very slight. Of course, it is much easier to lock the wheels on wet or icy streets than on dry pavements, but we are attempting to give the operator maximum safety when stopping and it is assumed that the careful driver will use caution when driving on wet or icy pavements.

In answer to the question as to how the outside front-wheels can be relieved of the braking effort when turning, since equal pressure is applied to all four wheels in the hydraulic-brake system, attention is called to the laws of deceleration and of centrifugal effect. In making a turn, the tendency is to increase the weight on the outside front and rear wheels and, as already explained, the application of the brakes tends to increase the weight on the front wheels, therefore the braking effort, when equally applied, locks the inside rear-wheel first, then in succession the outside rear-wheel, the inside front-wheel and, lastly, the outside front-wheel. The effect is automatically to allow the maximum braking-effort on a turn as well as on the straightaway.

The Trend of Large Commercial Motor-Vehicle Design

By A. F. Masury[1]

Metropolitan Section Paper *Illustrated with* Photographs and Drawings

ABSTRACT

REVIEWING the present transportation problem in regard to its demand for larger motor-vehicle units of transport, the author says that the motor truck is proving to be successful in the movement of practically all local freight and that the motorcoach is meeting with greater and greater favor as the logical vehicle with which to meet the demands of the traveling public for better transportation facilities.

Although the present types of motor vehicle are serving present needs in a more or less successful manner, when strict economics becomes the standard for measuring road transportation a demand will be made for vehicles that will accommodate the maximum freight or passenger loads in the minimum of street space. At speeds governed within limits of safety they will offer the utmost comfort for passengers and will haul perishable goods over long distances in quantities large enough to assure strictly economic operation.

Pointing out that the railroads long since discarded the four-wheel car as being entirely unsuited for freight and for passenger haulage and saying that more wheels must be called into service for motor vehicles if greater loads are to be carried, so that the axle loads may be kept within reasonable limits and that the weight on the roads can be distributed over as great a road area as possible, the author says further that, no matter what the ultimate multi-wheel motor-vehicle may prove to be, one of the intermediate stages of development will be along the lines of six-wheel and eight-wheel vehicles. Uses for such vehicles are enumerated and somewhat detailed descriptions are given of the six-wheel and the eight-wheel types in which the author is interested, inclusive of their operating characteristics.

BEFORE entering into any discussion of the general trend of large motor-vehicle design, it is necessary that we understand why the design of very large vehicles, such as six and eight-wheel motor-trucks and motorbuses, has even been attempted. A general survey of some of the recent developments in motor transportation brings to light a number of facts that have a very direct bearing on the type of motor vehicle which undoubtedly will be seen on our streets and roads in ever-increasing numbers.

While it is true that centers of population and of business follow transportation lanes, it is also true that freight-carrying and passenger-carrying transportation must each accommodate itself to such other agencies as have direct or indirect bearing on the location of business and residential centers. Previously, the automotive engineer has been too wrapped up in the problems incident to the design and service of motor vehicles to give any particular attention to the broader aspects of the case; in other words, automotive engineers have been forced by circumstances to shun any civic responsibility. The rapid development of the automotive field has left in its wake a multitude of complications which must be disposed of in the near future.

To meet the situation before it gets entirely out of hand, automotive engineers must become transportation engineers. To do this, we must study intricate problems which affect the welfare of the people as a whole and devise such corrective measures as will prevent the motor vehicle from becoming a menace. The motor truck has always been a progressive agent and, in order that it always shall remain an accessory of prosperity and progressiveness, every effort must be made to see that no stumbling blocks are placed in the path of its healthy and intelligently supervised development. Along this line, much can be done by cooperating with public officials. Investigations should be conducted in every community and a plan should be worked out which will permit the transportation problems of each locality to serve, in the best way, the needs of the community at large, as well as each individual industry.

Unlike railroad transportation, motorcoach and motor-truck transportation are the result of gradual research and development rather than the result of direct invention. Both have been instrumental in developing new fields of endeavor, but neither can be perfected so long as development is curbed by short-sighted legislation and policies. Intelligent and efficient coordination of all existing methods of goods and passenger haulage alone can effect an economical solution of transportation problems.

The present costs of transportation and distribution are too high in many cases. At a recent meeting called to discuss New York City traffic problems an authority stated that, out of every dollar required to transport goods from the source of production to the ultimate consumer, the railroad's share was only 13 cents. In other words, 87 cents is spent in incidental charges which, by way of comparison with the cost of railroad transportation, constitute a shameful waste.

This is a day of production methods when large sums of money are spent to obtain utmost efficiency, but as highway development and road construction have been unable to follow the rapid strides made by the automotive industry, the more or less haphazard method in which cities were planned originally is having an effect that cannot be offset entirely, even by the most efficient methods of transportation. Traffic regulations, motorbus regulations, city zoning and the like are doing much to relieve the resulting congestion. In fact, some of our larger cities are adopting wholesale measures in an endeavor to relieve congestion. Entire city blocks are being destroyed in order that an adequate outlet for the increasing volume of traffic may be provided. Such methods are too costly for general adoption, and the rebuilding of our cities to accommodate new conditions must, of course, be a slow process. The motor truck is proving to be the solution to the problem of practically all local freight movement, and the motorcoach is meet-

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ing with more and more favor as the logical vehicle with which to meet the demands of the traveling public for better transportation facilities.

The present types of motor vehicles are serving present needs in a more or less successful manner; but, when strict economies become the standard for measuring road transportation, a demand will be made for vehicles that will accommodate the maximum freight or passenger loads in the minimum of street space. These vehicles must be designed so as to permit speeds commensurate with commonsense and safety. They will offer the utmost in passenger comfort and will prove of great value in hauling perishable goods over long distances in quantities large enough to assure strictly economic operation.

The railroads have long since discarded the four-wheel car as entirely unsuited for either freight or passenger hauling. The principal reason for the adoption of more wheels has been the greater loads that all these cars must carry and the greater demands for comfort made by the patrons of passenger trains. While no direct comparison can be made between railroad development and road transportation, due to the limits placed on road vehicles by the roads themselves, it follows nevertheless that, if greater loads are to be carried, more wheels must be called into play in order that the axle loads can be kept within reasonable limits and so that the weight on the roads can be distributed over as great a road area as possible.

What the eventual multi-wheel motor-vehicle will be is, of course, impossible to state. Possibly, in the future, we may see both freight and passenger-carrying vehicles operating on caterpillar tracks developed to a state that will allow speed and at the same time be noiseless in operation. No matter what the ultimate vehicle may prove to be, one of the intermediate stages of development will be along the lines of six-wheel and eight-wheel vehicles.

Multi-Wheel Motor-Vehicles

Six-wheel and eight-wheel motor-vehicles can be used to good advantage at present. Massive trucks and motorbuses cannot be operated safely at high speeds on narrow or congested roads. A movement for the construction of super-highways is under way, and their construction and application has been ably presented in a recent paper entitled Changing the Horse-and-Buggy Road to Fit the Automobile[2], by S. D. Waldon. Once these highways are open for operation, no restrictive legislation should be permitted to limit their economic use.

Without question commercial vehicles should be treated as common carriers except, perhaps, that they be taxed only for the maintenance of the highways rather than on their initial cost, because the roads over which they run are public property. I believe that the fairest kind of taxation is one which takes into consideration the weight per inch of tire width. The maximum weight per axle limits the incentive of the designer. With four lines of traffic and trunk highways having grade crossings eliminated, speed limits and traffic regulations could be revised accordingly.

[2] See The Journal, December, 1924, p. 521.

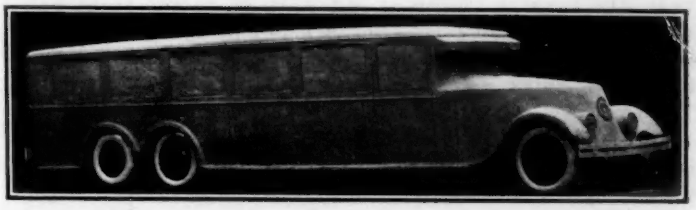

Fig. 1—Model of the Six-Wheel Motorcoach
Both Rear-Axles Are Driving Axles and Are Spaced 50 In. Apart. The Distance between the Front Axle and the Forward Rear-Axle Is 241 In.; Hence, the Mean Wheelbase Is 266 In.

Uses for Multi-Wheel Vehicles

The principal reason for the increasing popularity of the six-wheel and eight-wheel motor-vehicles is the demand from a critical riding public for riding-comfort, but I believe that this type of vehicle has an equal and perhaps a greater field of usefulness in the trucking business. The company with which I am connected has expended a great amount of thought and effort on this subject and has built what is probably the most advanced type of coach chassis on the market today. It was completed in October, 1924, and has since traveled many thousand miles on experimental tests.

While we were designing and building this chassis, we had the opportunity to fit a twin-axle unit, as used by a prominent motorbus operator, to an experimental motorbus. The drive was through the first axle only, and the other axle was used merely as a carrying and a braking element. The ease of riding of this makeshift assembly was better than that of any four-wheel job of my experience, the only disadvantage being that, when riding on wet pavement, one wheel slipped occasionally and thus reduced the amount of traction materially. Figs. 1 and 2 show two views of this six-wheel vehicle.

Six-wheel vehicles of the tractor-trailer type have been in commercial use for years. These have chiefly appeared where the pay loads are very long, such as aerial ladders for fire-department work; also, in package transportation, the milk business and the like, where the trailer body, with its ability for being easily detached, becomes a feature in loading or unloading.

Our Great-Coach chassis is of the six-wheel three-axle type; two are driving axles. The distance between the front axle and the forward rear-axle is 241 in., with 50 in. between the rear axle centers, thus making the mean wheelbase 266 in. Even with this seemingly long wheel-

Fig. 2—Chassis of the Six-Wheel Motorcoach
The Over-All Length of the Chassis, Including Bumpers, Is Somewhat Less than 35 Ft. It Has a Low Frame-Height, 21 In. above the Ground, but Still Retains Sufficient Clearance to Negotiate with Ease Any Ordinary Garage Ramp or Road Obstacle

base, the turning radius is but 36½ ft. to the right and 44 ft. to the left. The difference is caused by the drag-link interference; but this is not very important, because the sharpest turns are mostly negotiated to the right. The overall length of the chassis, including bumpers, is somewhat less than 35 ft. It has a low frame height, 21 in. from the ground, but still retains sufficient clearance to negotiate with easy any ordinary garage ramp or road obstacle.

The vehicle is powered with a 100-hp. six-cylinder engine of 4¼-in. bore and 6-in. stroke. The radiator is located between the engine and the cast-aluminum dash. The fan is of the squirrel-cage type and bolted on the flywheel, the air being expelled through a screen on the side of the hood. The clutch, brake and accelerator pedals, as well as the gear-shift and emergency-brake levers, are mounted so as to eliminate any hole or slot in the dash casting and floor, thus forming an effective seal from the engine compartment. The entire front appearance is suggestive of our distinctive AC-truck design.

The transmission is of the four-speed direct-on-high type and mounted separately, but as close to the clutch as the universal-joints will permit. Directly behind the transmission and separated from it by a short universal-shaft, the propeller-shaft brake is located, which, in conjunction with the front-wheel brakes, forms the emergency braking system. To the frame of this emergency brake is bolted the power-dividing unit; it consists of a high-speed bevel-gear differential and a set of spur gears to divide the engine power equally between two drive-shafts. Many important functions are performed by this unit. The only objection that can be made to it is that it introduces a few extra parts, but this disadvantage is greatly offset by the gain. It permits the use of lighter driving-shafts, joints, gears and bearings. It splits the high drive-shaft torque when climbing a grade on low gear. This is most important for trucking work.

Skidding is prevented to a great extent because of uniform driving and braking through each of the four rear-wheels. Difference of tire diameter, due to tire inflation, is fully compensated. Differential action is necessary as the tires change their diameter and circumference when under load. The road drag on the bottom of the tire deforms the tire considerably; for instance, if a tire is marked where it comes in contact with a slab of concrete and then the tire is rolled one circumference while the tire is under load and driving load, the change in circumference in the normal size of a pneumatic tire is nearly 1 in. This also prevents the sharp acceleration or retardation of the propeller shaft which would otherwise occur when the axles are displaced.

Fig. 3 shows the arrangement of this power-dividing unit and the drive-shafts leading to the forward driving-axle. The left shaft drives the first axle through a set of bevel gears and the right shaft is supported by two stay-bearings by the first axle and drives the second axle through a similar set of gears. The present experimental gear-ratio is 4.27 to 1 with 34 x 7-in. tires. With this ratio, a maximum speed of 60 m.p.h. has been attained experimentally and a fuel economy of 5.7 miles per gal. with a normal load. In the near future, other gear-ratios varying from the one already mentioned up to approximately 5 1/3 to 1 will be tried to get definite data for various road conditions.

The driving and the braking torques are taken by torque arms located on each side of the axle and inverted; that is, one is clamped to the brake spider of the forward axle and is free to rotate by being clamped in a rubber shock-insulator encased on the rearward axle and the other is clamped in an opposite manner on the other side. Thus, the torque of each axle is taken by the other axle, permitting at the same time any change of transverse axle-angularity occasioned by traveling on rough roads. Other arrangements of taking this driving torque are being tried out, such as taking the driving torque to the frame, and it is not yet clear in my mind which is the best method.

The axles are of the full-floating type and have a banjo forging similar to that of our smaller motorbus. These forgings are connected to the ends of two underslung springs by four rubber shock-insulators. The rear springs are of the cross type shown in Fig. 7 of my paper entitled Future Problems of Motorbus Engineering[3]. Each spring is composed of two semi-elliptic springs, the lower one being 50 in. long and 4 in. wide; it is pivoted in the middle to the other spring by a floating bearing attached also to the main spring, which is anchored to the frame in the conventional manner with rubber shock-insulators to form a Hotchkiss drive. This main spring is 64 in. long and also 4 in. wide. This construction was thought to be the best because of its minimum unsprung weight; in fact, the main springs are but half unsprung. Tests have shown that this arrangement permits maximum individual movement of each axle without binding.

The frame, of 32-ft. length, is split near the point of least loading. This was done because no press is large enough to form the side-rails in one piece and also to be able to make the rear channels so as to obtain maximum axle deflection and the lowest possible frame height coupled with adequate strength. The rear channels are slotted to take care of axle movement, and the open end of the slot is closed at the bottom by a secondary channel to form box construction. At this point the frame is 16 in. deep; it is 11 in. deep amidship, using material 5/16 in. thick, alloyed and heat-treated.

Steering and Braking

The need of easy steering is very great in vehicles of these proportions; it is obtained in this case by what is called center-point steering. It gives the maximum leverage between the hand and the tire on the road. Further, due to the fact that the center-line of the king-pin is almost in the center plane of the wheel, a change in tire

[3] See THE JOURNAL, November, 1924, p. 429.

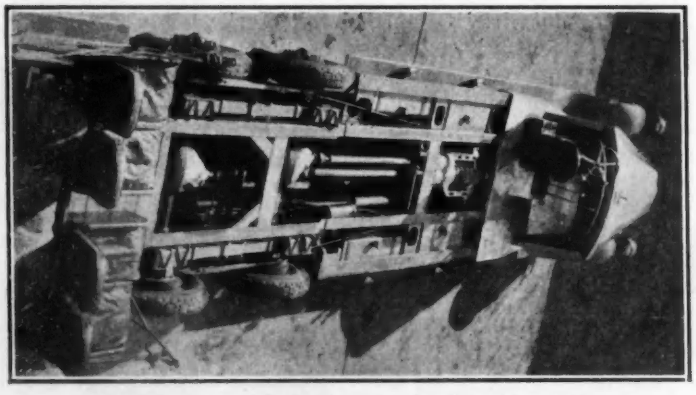

FIG. 3—COMPLETE SIX-WHEEL CHASSIS ASSEMBLY
This View Shows the Arrangement of the Power Dividing Unit and the Drive-Shafts to the Driving Axles. The Left Shaft Drives the Forward Rear-Axle Through a Set of Bevel Gears. The Right Shaft Is Supported by Two Stay-Bearings on the Forward Rear-Axle and Drives the Rear Axle Through a Similar Set of Bevel Gears. The Present Experimental Gear-Ratio Is 4.27 to 1 with 34 x 7-In. Tires. With This Ratio, a Maximum Speed of 60 M.P.H. Has Been Attained Experimentally and a Fuel Economy of 5.7 Miles Per Gal. with a Normal Load

inflation affects the steering but little. The front axle is of the inverted Lemoine type. The axle tread is 75 in. all around. In addition to the front springs, which are semi-elliptic springs 42 in. long and 3 in. wide, an additional quarter-elliptic spring is mounted on each side of the front end of the frame and connects it with the extreme ends of the axles in such a way as to absorb front-wheel-brake torque-reactions.

All brake drums have an inside diameter of 17 in. and have outside fins for cooling and stiffening. The front brake-linings are 3¼ in. wide and the four rear linings are 6 in. wide. The propeller-shaft brake has two drums, 8 in. in diameter and 7 in. wide. The combined brake-lining area is 1340 sq. in. The total chassis weight is 11,500 lb. and, if we assume 11,000 lb. for body and normal load, 1 sq. in. of brake-lining area is provided for every 17 lb. of total running weight.

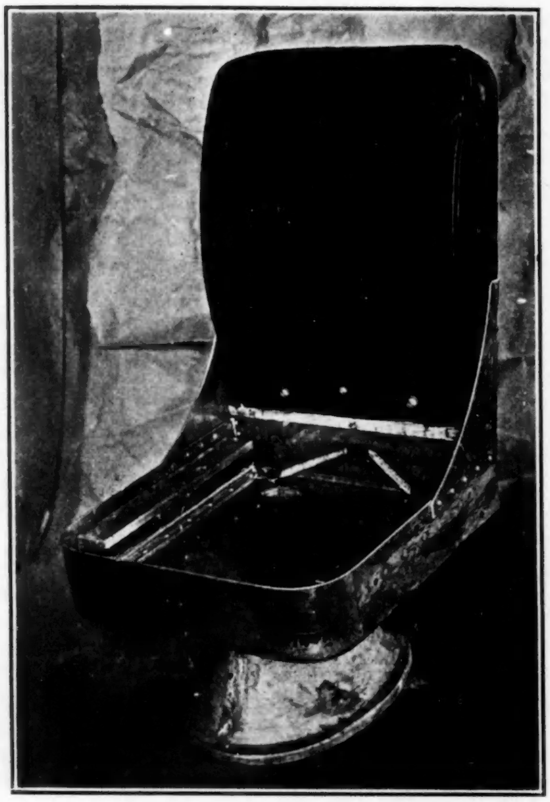

FIG. 4—SPECIAL MOTORCOACH CHAIR-SEAT
The Back Rest Is Integral with the Seat To Eliminate Friction on the Passenger's Back; It Is Made Adjustable To Suit Individuals and Is Intended To Decrease the Fatigue Occasioned by Long Rides. The Distinctive Feature Is That the Seat Is Suspended on ½-In. Cords, while the Frame Rests on Four Rubber Cups on the Floor. An Agreeable Rocking Motion Is Produced when the Coach Is Running

When traveling at 40 m.p.h., the kinetic energy stored in this vehicle is close to 2,000,000 ft-lb., which means that, to make an efficient stop, some sort of mechanical application of the brakes is necessary, especially when it is considered that 250 ft-lb. is about the maximum effort that human power can exert. The servo brake used on this chassis is located directly behind the transmission and is of the friction type. It consists of a friction disc and a plate that can be engaged by the pedal which, at the same time, applies the rear brakes. On this disc is a cam acting as a circular wedge which multiplies the frictional force available; as the cam rotates, it combines its effort with that of the pedal until the vehicle stops. This effort is proportional to the pedal pressure. The linkage is proportioned so that, when the brakes are worn out, the pedal strikes the floor. As there are two cams on the engaging plate, the servo mechanism operates equally as well when backing.

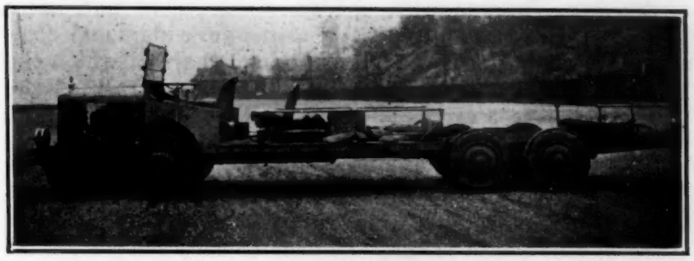

FIG. 5—EXPERIMENTAL EIGHT-WHEEL CHASSIS
It Has a Mean Wheelbase between Truck Centers of 201 In., the Distance between the Axles of Each Truck Being 40 In. The Axle Tread Is 70 In. The Two Rear-Axles Are Driving Axles

Fuel is supplied from gasoline tanks located on each side of the frame; they have an aggregate capacity of 42 gal. The fuel is pumped directly to the carbureter float-bowl by two magnetically controlled gasoline pumps. These pumps consist of a solenoid connected to a sylphon which acts as a piston pump, and the discharge is directly to the carbureter. The gasoline head of the full float-bowl is sufficient to stop the action of the pump. Current is supplied by the battery. As will be seen from Fig. 3, the controls are located on top of the fuse box, which is fastened to the left side of the driver's seat.

RIDING-QUALITY

Unlike Pullman-car riding, which imparts to the passenger a series of high-frequency motions of small amplitude, this six-wheel vehicle gives a succession of very slow motions very similar to the action of walking. This is a very pleasant feeling that no unnecessary noise mars, because each individual unit of this chassis is insulated one from another by rubber shock-insulated supports. Altogether 30 blocks of rubber of various sizes are employed for the supports, anchors and spring-shackles. These are held under compression, yet are free to move.

The tendency to increase the pay load in motorcoaches has rendered the tire problem a difficult one to solve. For instance, when dual pneumatic-tires are used, it has been found advantageous to vary the tire pressure for the inner and outer tire to compensate for sudden shifts in load and also to check this pressure periodically to obviate trouble. This involves special maintenance and extra cost for operators of large fleets. In the six-wheel vehicle, all tires are pumped to a like pressure. It has been found practically impossible to skid the vehicle, even on greasy and wet pavement.

Six and eight-wheel coaches already have seen a great amount of service in California, and operators report a tire mileage from 50 to 100 per cent greater than the mileage previously obtained. Hence, is it not possible that, although the initial cost is greater than for any standard construction, the saving in operation and maintenance quickly absorbs this difference and can show greater profits in the long run?

Great doubt has been expressed as to whether so large a vehicle as this can be handled easily through the city streets; but, since the vehicle has been on the road we have met with no traffic situation that we could not handle, and this includes passing through the narrow congested streets in Boston and the main streets in Newark during the rush hours, as well as around New York City.

To keep in step with chassis development and after giving serious thought to the passenger's personal comfort, we evolved a new type of de luxe chair in which the passenger is completely insulated from the rest of the vehicle, his feet excepted. Fig. 4 illustrates this chair, which has the back rest integral with the seat to eliminate the friction on the passenger's back. This rest is made adjustable to suit individuals and decrease the fatigue occasioned by long rides. The distinctive feature of this chair is that the seat is fully suspended on ½-in. diameter airplane-landing or Sandow cord, while the frame rests on four rubber cups on the floor of the

FIG. 6—FORWARD END OF THE EIGHT-WHEEL CHASSIS
Steering Is Done with All Four Front-Wheels and Is of the Center-Point Type. The King-Pins Are Vertical. The Over-All Length of the Chassis Is 27 Ft. 11 In., and It Weighs 8300 Lb.

body. The cord is wound and arranged so that a part of it damps what is left of the starting and stopping jolts of the motorbus, while the other portion produces an agreeable rocking motion that is limited and snubbed. A cord adjustment is provided in case the cord stretches, but this condition has not yet occurred in experimental chairs and the adjustment may never be needed.

The chief requirements of seat cushions are that they be softeners and eliminators of friction. These qualities are obtained in this design by the use of picked hair for friction and stitched cushions to eliminate the use of undependable small springs and prevent hardening or spreading. The seat itself is shaped so as to fit the contour of the body and permit uniform loading. Of course, one might raise the objection that the cost of this chair is considerable; but it is not, for de luxe traveling.

No doubt the question will arise as to why rubber is used in so many places. The answer is that ease of riding requires not only that the passenger ride without bouncing, pitching or rolling from unevenness of the road, but also that he be unaffected by high-frequency vibrations of very small amplitude set up in the vehicle itself, due either to road impact or to operating conditions. On the other hand, absolute rest would soon become uncomfortable, and a certain amount of motion to permit the necessary inter-friction of the body tissues has a beneficial effect when coupled with the sense of speed. The most healthful and least tiresome exercise is walking. I believe that conditions which can produce its action upon the human body fill the requirements of comfortable riding.

When a moving vehicle is subject to road-shock, every part of it reacts within itself, as a very high-frequency spring, due to its rigidity. Steel will continue to vibrate for a considerable time on account of the slow absorption of the energy by intermolecular friction. What is wanted then is a kind of material that will absorb the greatest amount of energy without transmitting high-frequency vibrations. Rubber answers these demands better than does any other material. It can store about 50 times as much energy as steel and, due to its greater deformation, it absorbs much more of this energy. Its use in place of mechanical joints eliminates lubrication. It is surprising that engineers have not taken advantage of these important properties before.

EIGHT-WHEEL MOTOR-VEHICLES

Before concluding this paper, I would like to present some data regarding an experimental eight-wheel chassis that has been brought to my attention. This design, which is shown in Fig. 5, has a mean wheelbase of 201 in. between truck centers, if they may be so called. The distance between the front and the rear wheels, of each truck, measured longitudinally, is 40 in. The axle tread is 70 in. all around.

The two rear-axles are driving axles. A power differential is located in the forward axle and is driven by a set of bevel gears from the propeller-shaft. One gear of this differential drives the forward axle, which has its own differential as well but located off-center. The other gear drives a bevel gear and pinion which, in turn, drive the universal shaft connecting the rear axle, an identical set of gears being used to drive the wheels of the rear-ward axle to permit interchangeability. The frame, of conventional design, is kicked-up over the axles.

The spring-suspension is of the compensated-action type and is composed altogether of 12 springs, six for the four front-wheels and six for the rear. Each set of three springs has three-point frame-support. A semi-elliptic spring is underslung under each axle, as shown in Fig. 5 of my previous paper[4], is anchored at the front end, which is the longest, and takes the propulsive effort. The short ends are connected by long shackles to another inverted semi-elliptic spring anchored to the frame at the middle. This spring is 40 in. long; each one of the two other springs is 36 in. long. Steering is done with all four front-wheels through vertical king-pins and practically center-point steering. Fig. 6 shows the front end. The over-all length of the chassis is 27 ft. 11 in., and it weighs 8300 lb.

SUMMARY

The opportunities offered for the use of six-wheel or eight-wheel motor-vehicles in the field of transportation are almost unlimited. Our aim is to occupy the minimum road space per passenger or per ton of merchandise while operating at the maximum safe speed and, when, due to city planning, easy access to each community center is provided as well as routes for going through it, and when the circumvention of community centers is practicable by using bypass routes, then we shall see mass transportation by motor vehicles. The growing need for more economical transportation is gradually paving the way for larger vehicles.

I realize that considerable remains to be accomplished before definite specifications can be outlined for the larger types of commercial vehicle. Their ultimate success lies in the future development of the highways of the Country, and the development of larger vehicles that

[4] See THE JOURNAL, November, 1924, p. 428.

have a better distribution of the load of the vehicle on the road.

THE DISCUSSION

R. E. PLIMPTON[5]:—Some questions that occur to me are: Why do we want more than four wheels on a motorbus? Is it to provide better riding-quality, when many of our present difficulties have nothing to do with the number of wheels? Is it to secure longer useful life or, stating it in a different way, to bring about lower operating-costs, when the multi-wheel motorbuses so far proposed are built and give no great promise of this, under "comparative" conditions? Is it to permit taking advantage of inherent flexibility, often said to be the greatest asset of the motorbus? Does the glorified automobile provide a vehicle that is better adapted to the transportation economics of the situation? Has it more seats per unit of area of highway required or per pound of vehicle weight? Finally, how does it fit in with such operating-conditions as are experienced on heavily traveled highways or congested city streets? Questions such as these are being asked by the transportation world.

The paper dealt mainly with a rigid construction that, fundamentally, offers many of the same difficulties now being experienced with four-wheel motorbuses, and these may even be exaggerated on account of the longer dimensions. Maneuvering and clearance possibilities can be mentioned as examples. It seems desirable, therefore, to consider the tractor-trailer, with its relative ease of maneuverability. Of course, the small steering circle can be obtained with the rigid vehicles by using an unusually sharp steering-lock angle, or by the steering of the rear set as well as the front pair of wheels on six-wheel vehicles. This does not give the body flexibility, however, which is possible with some form of articulated construction. The placing of the four wheels at the front, all arranged for steering, and two wheels at the rear might simplify both the problems of driving and of steering.

One of the first examples of this construction used for transportation work in this Country was an elongated Ford touring car that, a year or more ago, ran between Old Orchard Beach and Ocean Park in Maine. This motorbus retained the front and the rear wheels, but an extension was built at the rear end and extra body space was secured over another set of rear wheels. The original set of rear wheels was connected with the front wheels so that the rear set steered. With this four-wheel steering, it was possible almost to double the wheelbase. Thus, the center-to-center distance between the three axles was almost equal.

Some development of the articulated multi-wheel vehicle has transpired in this Country, but the vehicles built have not been of the size or capacity to show the possibilities of the design. Much more along this line has been accomplished in Europe. About a year ago an eight-wheel chassis, designed to accommodate 64 passengers in a double-deck body, was described in the English periodicals. This Rokeby Transporter can turn, it was said, in a 25-ft. street, without any reversing, although an extra 4 ft. on each side would be required for overhang. The drawings showed four wheels set on an 84-in. wheelbase. Four-wheel drive was proposed for the tractor, and a rather complicated friction device serves for clutch and transmission. Another novelty was proposed in the four wheels at the rear end of the trailer. Normally, these would be almost in line across the chassis,

[5] M.S.A.E.—Associate editor, *Bus Transportation*, New York City.

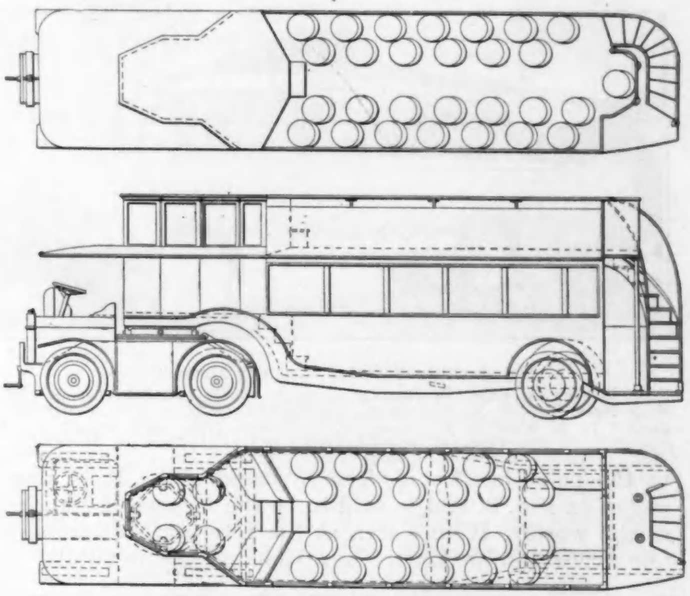

FIG. 7—THE ROKEBY TRANSPORTER
This English Tractor-Trailer Type of Motorbus Was Built for Exhibition Purposes Only as According to the Law, It Cannot Be Operated in England. Steps at the Center, Inside, Give Access to the Seats Mounted over the Tractor Portion. The Top View Is a Plan of the Upper Deck, That of the Lower Deck Being Shown at the Bottom. This Motorbus Has a Right-Hand Drive

similar to dual rear-wheels, except that pairs on each side were separated by the frame members. The mounting was such, however, that the wheel could move backward and forward on a hinged arm, a pulley and cable differential connection being provided to the ends of cross-springs, so that any road-shock would be divided equally between the four wheels. These springs were of the semi-elliptic type but were mounted between the main frame-members on a cross support.

Fig. 7 shows the Rokeby Transporter, an English tractor-trailer type of motorbus that was built for exhibition purposes only. According to the law, it cannot be operated in England. Steps at the center, inside, give access to the seats mounted over the tractor portion. The top view is a plan of the upper deck, the middle view shows the side elevation, and the lower-deck plan is the view at the bottom.

In Germany, some development work seems to have been done recently in the six-wheel rigid-type. Some advertising in a November, 1924, copy of a German transportation periodical features a 70-passenger single-decker by Vomag. Instead of having the two rear axles fairly close together, the distance between them was about one-quarter of the body length as was also the overhang at the rear end, leaving about half for the space between the front and the second axles. This vehicle was designed with the driver's position to the left of the engine with a door opposite. An entrance door for the passenger was located just back of the driver's door, with another passenger door at the rear end. A monitor construction was used in the roof, and the curtained windows gave every indication of a luxurious interior well fitted for the purpose recommended in the advertising, which was *reisenluftbereitung*, or feeder service to the air-transport system.

The Bussing Company had another six-wheel motorbus illustrated in the same issue of this periodical that had much the appearance of the Goodyear construction developed in this Country. The driver's position was back of the engine and a step for passengers was placed at the rear end. This was featured rather briefly but

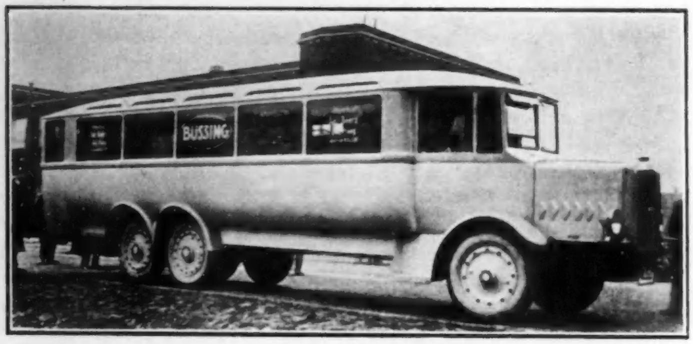

FIG. 8—THE WORLD'S LARGEST MOTORBUS
This Motorbus, Said Te Be the Largest of Its Kind in the World, Was Seen at the International Automobile Exposition in Amsterdam. It Is Similar to Large Motorbuses That Are Being Tried Out on the Boulevards in Paris

to the point as *Die Modern Strassenbahn.* It is illustrated in Fig. 8, and is said to be the largest of its kind in the world. It was seen at the international automobile exposition in Amsterdam, Holland, and is similar to

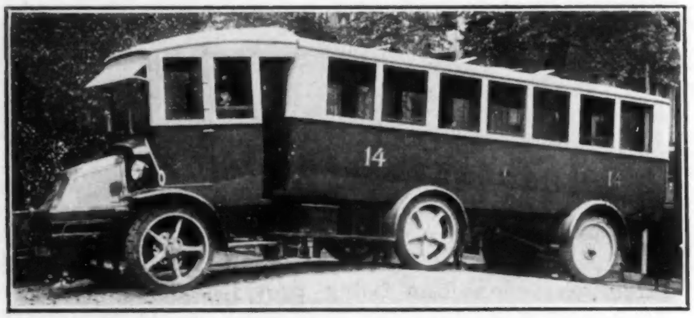

FIG. 9—LATIL ARTICULATED SIX-WHEEL MOTORBUS
This Vehicle, Which Is of the Tractor-Trailer Type and Has Front Drive, Is Used in Amsterdam, Holland. It Seats 29 Passengers and Has Standing Room for 10 More

large motorbuses that are being tried out on the boulevards in Paris, France.

Fig. 9 shows the Latil articulated six-wheel motorbus of the type used in Amsterdam, Holland. Seats are provided for 29 passengers and standing room for 10 more. It is of the tractor-trailer type and has a front drive.

Center clearance is the limiting factor of motorbus length between wheelbases. I know of some motorbus routes in this Country on which a motorbus having a long wheelbase cannot be used because the drive has not sufficient clearance as at grade crossings and at the entrance to some garages.

Fig. 10 illustrates a type of emergency exit through a motorbus roof. In Holland, danger exists that a motorbus loaded with passengers may run into or slide off into a canal. Police regulations therefore require a rear and a top emergency exit. In this type, six people can emerge through the roof exit.

In closing, I agree with the previous speakers that a distinct field for the multi-wheel vehicle for passenger transportation, at least, exists and possibly for the carrying of perishable or fragile freight and for war work. But the operating companies are interested in a complete vehicle, and enthusiasm about the more-than-four-wheel type will never compensate for the lack of attention to other important units that require development.

E. W. TEMPLIN[6]:—The Goodyear Company began active development of the six-wheel motor-vehicle in the spring of 1919. In January, 1920, a complete truck was built. To date, that truck has traveled 96,000 miles. The only change made was in the method of absorbing the torque between the two axles. The original design was a sort of cross-tube arrangement which was changed to the telescoping-tube arrangement. The cost per mile of operation of that truck has been very low as compared to two different makes of truck that probably are on the market in largest numbers. The cost of operation was about two-thirds of the total cost of the other two makes. Succeeding models were built, using different kinds of drive. The third vehicle built crossed the continent from Los Angeles to New York City in a driving time of 6½ days. The best previous time made in the previous year was by a Packard super-truck, in 13½ days. That Goodyear truck is now running and has traveled something like 76,000 miles in service. The design is being commercialized now. It is being put on the market by the Six Wheel Co., of Philadelphia and also by the Moreland Truck Co. on the Pacific coast. Probably the most recent development is the introduction of the six-wheel vehicle into Detroit for use under the double-deck motorbus-bodies there.

Tire mileage on these trucks was consistently greater than in any four-wheel construction that the Goodyear Company operated, and when it came to making contracts for tire equipment on the double-deck motorbuses in Detroit, Goodyear quoted a unit price per bus mile that represents a tire mileage of somewhere between 20,000 and 30,000 miles. Other tire companies desiring the business bid on a competitive basis.

As to how the brakes are operated on the six-wheel vehicle, the rear truck is trunnioned at the frame and has a spring deflection that lengthens; so, if the brake-rods are arranged to come to the center of that trunnion, any oscillation is handled automatically. Then, if also that center is arranged at a certain height, depending of course on the character of the spring, the rods will lengthen out just as the spring deflects. That gives the fundamental idea of taking care of the mechanical brake on that job. All our jobs have been built according to that scheme and we have always had good brakes.

ROLAND CHILTON[7]:—Regarding the statement that one of the advantages of having many wheels is a greatly

[6] M.S.A.E—Chief engineer, Six Wheel Co., Philadelphia.

[7] M.S.A.E—Engineer in charge of engine division, Aeromarine Plane & Motor Co., Keyport, N. J.

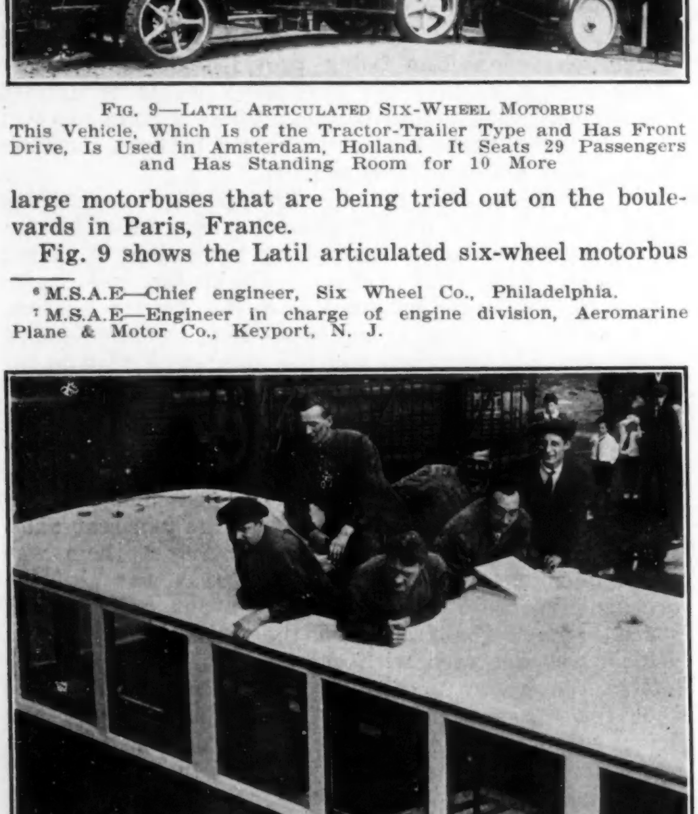

FIG. 10—TYPE OF EMERGENCY EXIT THROUGH A MOTORBUS ROOF
In Holland, Danger Exists That a Motorbus Loaded with Passengers May Run into or Slide Off into a Canal. Police Regulations Therefore Require a Rear and a Top Emergency Exit. In This Type, Six People Can Emerge through the Roof Exit

increased braking-effect, for example, in the construction described by Mr. Masury where a propeller-shaft brake is used, I do not understand how the brake knows how many wheels are back of it. It seems to me that the tractive effort, which is the ultimate limitation on the deceleration rate, is not a function of the number of wheels but of the percentage of all the wheels to which a brake is applied. We seem to succeed in applying brakes to 100 per cent of either four or six wheels. The only advantage of the multiple wheels in that particular respect is that convenient space is afforded for a large brake area.

WILLIAM P. KENNEDY[8]:—Fig. 11 shows a tractor semi-trailer type of motorcoach, the tractor being coupled to the semi-trailer by a separate fifth-wheel connection. The union of the body parts on the tractor and on the semi-trailer chassis is maintained by a spherical cowl so that, during any angular changes between the tractor and the semi-trailer, complete closure of the body compartment is secured at all times. The entire power equipment is in the tractor; hence, the body can be built as low and as wide as desired. As the rear wheels are steering wheels, the length of the vehicle can be made to any dimension within reason. The vehicle as shown in this illustration has a 78-in. wheelbase for the tractor and a 148-in. wheelbase for the semi-trailer; it has a turning radius of 26 ft. and is equipped with brakes on the tractor driving-wheels and also on the rear steering-wheels.

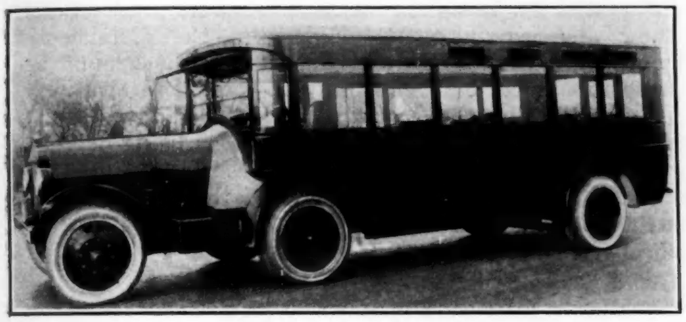

FIG. 11—TRACTOR SEMI-TRAILER TYPE OF MOTORCOACH

The Union of the Body Parts on the Tractor and on the Semi-Trailer Chassis Is Maintained by a Spherical Cowl So That, during any Angular Changes between the Tractor and the Semi-Trailer, Complete Closure of the Body Compartment Is Secured at all Times. The Entire Power Equipment Is in the Tractor; Hence, the Body Can Be Built as Low and as Wide as Desired

The advantage of this type of vehicle is that it has better distribution of the load on the working axles than exists when the two axles are in the rear. In this particular machine shown in Fig. 11 the load distribution is 40 per cent on the rear wheels, 45 per cent on the middle wheels and 15 per cent on the front wheels. The over-all length of the vehicle for 25 passengers is 25 ft. 8 in. With the same over-all length and wheelbase and a double-deck semi-trailer body, the seating capacity can be increased to 67 passengers.

Fig. 12 shows the construction of the chassis and the method of connection between the tractor and semi-trailer. Separation whenever desirable can be readily accomplished, so that an interchange of bodies having different capacities is feasible.

A. M. WOLF[9]:—When some of us looked at Alexander Dow's dual-driving-axle truck with its chain-drive interconnection many years ago, we swallowed the proverbial "grain of salt," which seems only now to have just about gone through the digestive stage.

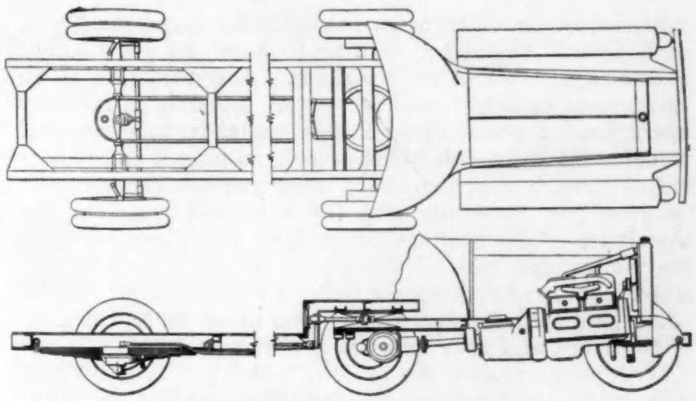

FIG. 12—CHASSIS CONSTRUCTION AND METHOD OF CONNECTING THE TWO PARTS OF THE VEHICLE

Separation of the Tractor from the Semi-Trailer Can Be Accomplished Readily, So That an Interchange of Bodies Having Different Capacities Is Feasible

In attacking various problems, in matters of either load or power capacity, we finally come to a solution through the use of multiple units. And so I feel that the six-wheel or, even the eight-wheel, vehicle has its legitimate field, surely in the larger type of motorbuses and also in certain freight-transporting vehicles. Motorbus design is already being reflected in truck construction and will be more so in the future. We see moving-van and furniture bodies mounted on motorbus chassis already. So I feel that, where time is an element, the transportation of freight in large trucks of the six-wheel type is bound to come immediately, with its more general adoption later.

The rail-car, while not entirely similar to the vehicle on the highway, has many points of similarity. Almost everyone started with two driving wheels in the rear, which is being abandoned for the four-driving-wheel type. This analogy should stimulate the multi-axle idea.

In the matter of differentials, I cannot see how it is necessary to provide one between the two axles. In view of A. W. S. Herrington's experience with military trucks in this regard, which confirms some work that I have done with passenger cars, the differential in this particular place seems superfluous. Considering a large-type six-wheel motorbus, in making a quarter turn, if any slip occurs between the outside wheels, assuming that the center of turning should not be exactly on the prolongation of a center-line midway between the axles, it could not amount to more than a few inches in a travel of from 45 to 50 ft. The fact that the wheels are not tangent to the circle they describe, seems to me to be a larger item than the differential problem, if we believe we have any problem at all. I think many of us are apt to be too theoretical; and, were tires geared to the road like a rack and pinion, this would be true. But, in actual running, the road is not perfect; more or less bouncing of the wheels occurs and a transfer of the load from one side to the other. Particularly, inasmuch as these motorbuses travel on improved roads where the turning radius is very large, the differential seems to me to be an unnecessary addition.

In a four-wheel-drive truck, similar to the military type, I can see that a necessity for a differential between the two axles might exist. In going over rough ground, it is conceivable that a front axle might have to mount a knoll or other sharp rise, while the rear is still on the level. For a 1-ft. advance of the latter, the front wheel-

[8] M.S.A.E—President, Kennedy Engineering Corporation, New York City.

[9] M.S.A.E—Chief engineer, I. Sekine Co., New York City; Arthur Rehberger & Son, Newark, N. J.

center may travel through considerably more than 1 ft. as it travels upward as well as forward, in which event a differential would be desirable. However, this is an exceptional case but one that is very possible in military operation. I would favor a differential in this case but would want it provided with a lock, so that it can be unlocked in such emergencies. No comparison can be made between the foregoing and the six-wheel type, as the wheelbase of the military truck is so much greater than the center distance of the two rear-axles of the six-wheel type. Furthermore, the two rear-axles would never be disposed on uneven ground as would be the case of the front and rear axles of a four-wheel type.

With smaller axles, the price of which is attractive and which are available because of large-production runs, greater ground-clearance is obtained and having a smaller axle-housing enables us to bring the frame closer to the ground, a desirable item in motorbus design.

The six-wheel type of construction enables us to lay out a better suspension system, due to the smaller axle units and their reduced unsprung weight, and also to the fact that we have more room in which to work and can overcome the full intensity of impacts. Most jobs are built too rigidly in many ways, and in the suspension phase we are offered a means of relief in this respect.

A. F. MASURY:—Mr. Dow built the first vehicle of the six-wheel type in 1911 or 1912. It operated very satisfactorily as a commercial vehicle for a number of years, and had a chain-driven rear end, one chain driving to a front wheel and two wheels chained together. A casting which held the two wheels was pivoted to a main axle. Mr. Dow went into the subject very fully and has worked on it in a designing way ever since. Recently, he showed me some very interesting work he had been doing along this idea of differentials, although somewhat different. It was not in any sense a conventional differential, but was a differential that allowed the two wheels on one side to work as one with the wheels on the other side because of a change of length of the distance-rod between the two axles. He mounted sections of gears on a board and had two wheels which fitted into cogs that traversed the board's surface. He pushed a miniature bogie truck along with his hand and it assumed a position as does a differential that will lock if you drive only one wheel; or, if he pushed the bogie truck, he could show definitely that while going over certain curves some sort of differential action between the wheels had to take place, that is, if they were geared to the ground and I think they are. I defy anyone to take a load of 7 tons on eight wheels and move a pneumatic tire around with a crowbar or any other lever. It will not slip. Mr. Dow, to accomplish this action without using the conventional differential has made the distance-members pivot on each elbow and, as the wheel closes in, the distance-rod lengthens and shortens with relation to the ground because the drive is from a central point. In that way, one wheel is allowed to catch up with the other as it goes over the bumps. I mention the device as being original, novel and entirely a different differential action from any other of which I have heard. I think much credit is due Mr. Dow because he is the pioneer of the six-wheel-vehicle design in this Country.

ENGINE TEMPERATURE

IT cannot be conceded that carbureters are so faulty as is sometimes inferred. It is in matters subsidiary to the carbureter itself that the average motor car evidences shortcomings. With badly formed induction pipes, faulty internal design in the way of heads and ports, badly placed ignition-points and unsatisfactory valve-gear and timing, reasonable results are impossible. No induction system will give satisfactory service while operating at wrong temperatures. Few cars are designed so that the correct running-temperature is maintained. An immense quantity of fuel is thus wasted every day. This fuel is not merely a loss; it is used mischievously to destroy valves and castings, form carbon deposits and generally lower performance.

No car with an open-fronted radiator or an uncontrolled water-circulation system can hope to give a full measure of fuel economy and thermal efficiency. It is unscientific to arrange for the carbureter alone to compensate for the very varied conditions of every-day running, particularly when it is insisted that the carbureter shall function with one control only. Moreover, this control has, after all, not much to do with carburetion. It functions merely as a tap, namely, the throttle.

Allied with the problem of the open-fronted radiator is the matter of the two large openings into the bonnet which are found one on each side of the engine. It is not customary nowadays to fit trays or aprons. In consequence the average carbureter is exposed to a succession of powerful and varying gusts. This is bad enough, but it frequently happens that the air intake is so positioned that the gale in the bonnet is allowed to have the fullest possible disturbing effect. No fixed value for the cooling system can possibly be correct, the bonnet should not be open to the wind, and mixture strength should be in some measure controllable by hand. It is obvious that present-day cooling methods cannot meet the very varying requirements even in temperate climate. In England the temperature range is sufficient to justify proper engine-temperature control. This is necessary if for no other reason than that the great majority of cars are used for short distances and may be started up from cold several times in a single working-day. Ordinary running conditions vary hour by hour as the weather, the load and the character of the road and the running changes. These are normal working conditions. The general trend to apply a radiator muff in the winter testifies to the need for apparatus of the kind indicated, the use of these muffs being an unsatisfactory makeshift.

It is frequently contended that the time is not yet ripe for mixture-strength controls, and bearing in mind the remarkable stupidity that non-mechanical individuals can sometimes evidence it would seem that some reason exists for this contention. It should, however, be possible to limit the potentialities for mischief by limiting also the control range. The aim should be to permit at least of weakening the mixture. In this way non-technical drivers could be restrained from running the engine too rich. As controls of this kind became more customary, users would undoubtedly become educated to their management. Considerable benefits in fuel saving would be secured as well as a cleaner engine. Proper temperature in the engine and the combustion system will cover a multitude of sins. It minimizes the effects of many design compromises, such as imperfectly shaped pipes and ports and poor design of head.—*Automobile Engineer.*

Pyroxylin Refinishing-Practice

By J. J. Riley[1]

New England Section Paper

ABSTRACT

RESEARCH development of finishing materials of the pyroxylin type, as conducted by the company represented by the author, finally resulted in the refinishing system he describes. The basis of the finish now developed is a type of nitrocellulose known as pyroxylin. Its basic material is cotton, specially purified and nitrated. After a process to prepare it for the admixture of solvents and gums, the resultant clear liquid is mixed with finely ground pigments and this produces an opaque pyroxylin-enamel that dries by evaporation.

Three methods of stripping the old finish are outlined; these involve the use of paint and varnish removers, of alkali removers and sand blasting. Details of refinishing the running gear and the body are clearly stated.

IMPROVEMENTS in body design and mechanical construction of the modern motor car are made year after year but, until recently, and long before the car showed the effects of wear mechanically, its finish had deteriorated to such an extent that in many instances it presented an unsightly appearance. Manufacturers did much research work with finishing materials of the paint and varnish type, with the idea in view of giving longer life to the finish. The automotive industry installed elaborate baking systems and great effort was made by all to attain greater durability. Having for years been engaged in the nitrocellulose industry, the company I represent turned to its research department and undertook the development of finishing material of the pyroxylin type. Research work was conducted during several years. Many obstacles were overcome and, finally, the principles of the new pyroxylin finish were evolved. I will describe the product briefly, telling what it is, how it differs from paint and varnish and of its method of application.

The basis is a type of nitrocellulose known as pyroxylin. The basic material is cotton, specially purified and nitrated; it then goes through a process to prepare it for the admixture of solvents and gums. The resultant clear liquid is then incorporated with finely ground pigments, and this produces an opaque pyroxylin enamel. The formulas of all the shades are perfectly balanced, years having been spent in development work to attain this end.

This type of enamel dries by evaporation. It really is chemically inert, friction being the only agent that has an appreciable effect on it, although of course it is affected by its own solvents, alcohol being one; hence, we warn manufacturers to post their dealers on the fact that anti-freeze solutions containing in excess of 25 per cent of alcohol will penetrate the finish if splashed or allowed to boil over on the hood, although this will evaporate very quickly and the stain caused can in most cases be removed by the use of our No. 7 polish if the job is attended to immediately. The colors selected for the formulas are permanent ones and no appreciable fading is noted in the finish.

Excessive heat, cold, moisture and the like cause reactions that lessen the life of the finishes of paint and varnish type that dry chiefly by oxidization and are constantly undergoing chemical changes. Progressive oxidization takes place during which the finish is growing less elastic and more brittle, until it can no longer expand and contract with the metal; this results in checking, cracking and flaking. Meanwhile, the actinic rays of the sun are attacking the finishing varnish and gradually changing it into a dull lifeless coat; within a relatively short time the finish loses its bright glossy effect that was so attractive to the buyer when the car was new.

We have test cars now on the road that have been out more than 2½ years, and the luster of their finish has really improved with age. The finish of their hoods has not faded; whereas, on test cars having high-grade varnish-finishes, the hood finish has faded very badly, due to the heat of the engine. The test cars having pyroxylin finish have had many abuses, but we find that ordinary soap, gasoline, oil, grease, ammonia, battery acid, pyrene and even alkali dust have had no effect on this impervious finish. Two of these test cars are in the salt air practically all the time; ordinarily, that has a very bad effect in breaking-down a varnish finish, but the finish of these two cars today is in very good condition.

Supplementing these physical time tests on cars, we have many exposed-panel tests in progress in the North and also in the South, one set being in Florida. These panels are examined periodically to ascertain the effect of time on the film; they all look very well except those in which lake pigments have been used in the making; hence, we have withdrawn maroon shades from the market. Maroon color varnishes are fugitive to light and always fade out quickly. Although maroon shades of our finish outlasted color varnishes, they were not typical of pyroxylin finish as to length of life and were withdrawn after having tried practically all maroon lakes manufactured here and abroad. To substitute other red pigments would result only in bricky, muddy casts having nothing like the rich deep brilliancy of a true maroon.

Application and Refinishing

In connection with the application of this finish, the automotive industry, in conjunction with our service department, has worked out many simplified methods for production and for refinishing shops. The automotive industry, with all its modern facilities, such as baking equipments for undercoats and the like, has reduced the cost of application materially and has attained wonderful results in the polishing operation, thus producing a finished job having a refined luster that can be maintained indefinitely by using our No. 7 polish occasionally. A polish that leaves a film on the surface is not satisfactory. The abrasives used in our rubbing and polishing compounds rub or buff the surface down to a smooth light-reflecting coat.

In connection with refinishing, we have before us conditions that differ radically from those in production shops. First, the stripping of the old finish presents a vital step in the process. After the car has been pre-

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pared for stripping, by removing all parts that would in any way interfere with the refinishing, we have the following three methods of removing the old paint:

(1) *Paint and Varnish Removers.*—This method is very effective, provided a remover is used that has strong penetrating qualities and carries the minimum of paraffin wax. If any wax is left on the surface it will cause trouble that will be manifested in the non-drying of the pyroxylin coats, and this is an expensive trouble to correct

(2) *Alkali Remover.*—This method is being used by many; a number of alkali systems are on the market. Great precaution must be taken to protect upholstery and window felts. In fact, the alkali system should not be used on closed jobs above the molding; it is likely to cause trouble where there are many wooden posts on cars of the older models, and some of the alkali and water is likely to get under the moldings, causing chipping and breaking away from the molding. Great care must be taken when using an alkali remover in the preparation of the car to make sure that none of the remover penetrates to the interior. It also is necessary to make sure that the alkali is neutralized, washed off and driven out of every crevice. For aluminum bodies, we prefer paint and varnish remover, due to the action of alkali on the metal

(3) *Sand-Blasting.*—This method calls for the complete dismantling of the car, and the removal of the body from the chassis. Only a large production warrants the installation investment. It is a very effective means of cleaning and equipment cost will be reduced. The removal of the body from the chassis is not wholly satisfactory in most cases as, invariably, it cannot be set back when the work is completed so that it fits as it did before. Later day developments in sandblast equipment have improved this method of cleaning and, recently, I witnessed a demonstration of this method, without taking the body off the chassis, the engine and other parts being protected with rubber coverings. However, from my viewpoint, the method is still in the experimental stage

After the paint has been removed by either of methods (1) or (2), the job must be cleaned and sanded smooth with fine paper manufactured for this purpose. All moldings and seams must be gone over with a blow-torch to remove any foreign matter; if the premises are laid out so that a fire hazard is not incurred by so doing. Then, the entire body should be washed with denatured alcohol, high-test gasoline or turpentine; spaces 2 ft. square should be worked and then wiped off before any of the solvent is dry, being careful not to foul any previously cleaned surfaces. To detect and eliminate foreign substances like paraffin, a coat of thinner should be applied on any places where the pyroxylin coat does not dry, fine abrasive should be used immediately and the place washed again with any of the foregoing solvents. Rust should be removed with Deoxidine or any other approved rust remover. The job is now ready for priming. The sooner it is primed the better, as a newly cleaned job will rust very quickly.

Refinishing Running Gear

Cleaning wood wheels is a difficult task. The only proper ways are either to burn off the old finish with a blow-torch or to sand down to the lead coat and then build up with primer, putty and surfacer. Where the wheel finish is burned off, it is necessary to use a long oil primer, adjusting it to take care of the absorption of the wood, following this by surfacer and hard-drying putty if necessary. Then the pyroxylin coats are applied. Disc wheels should be cleaned off, primed, surfaced, rubbed out and pyroxylin finished by the same method as that used on the body.

The chassis should be cleaned with an alkali system and finished in chassis black of the paint type. Where an alkali system is not in use, the chassis can be washed down with gasoline, the rust spots sanded and the whole finished with chassis black. Pyroxylin finish can be used on the chassis, but the expense of preparation due to cleaning and priming is excessive at present; hence, we recommend chassis enamel of the paint type.

Fenders, if they are not to be treated with pyroxylin finish, can be stripped in the lye tank or with remover compound, although the latter is expensive because high-bake enamel is difficult to clean off with remover. Great precaution should be taken to remove rust from the under side of fenders, and then these parts should be coated with heavy-body chassis black-enamel. The fenders should be primed, puttied if necessary, have surfacer applied, be rubbed out and then coated with pyroxylin finish. As all fenders are finished in practically the same way, with black baking-enamel, it is possible to apply pyroxylin coats without removing the old finish. Simply clean the rust spots with emery paper and follow this by a complete sanding off of the entire fender with abrasive paper and alcohol. Clean up and apply a coat of blue diamond dark oxide metal primer; putty if necessary and follow with at least one coat of surfacer; then spray-on pyroxylin coats. Although somewhat more expensive, we find that it is much better to remove the old enamel from the fenders; thus producing a long-life job.

Body Finishing

The priming coat of the body of the car should be reduced to spraying consistency with turpentine, and a light coat of primer should be sprayed on. The primer can be brushed on if so desired, great care being taken not to apply too heavy a coat. Our primer should be given 24 hr. in which to dry at a room temperature of 60 deg. fahr. or above.

After the primer has dried, all rough spots such as file and hammer marks in the metal should be brought up with putty-glaze. Some metal is so rough that it is necessary to knife glaze all over the body; other metal is rough in sections only; therefore, judgment must be used as to how much putty-glazing should be done. Just enough putty to fill up the marks should be used, and it should be put on as smoothly as possible to prevent ridges. Putty should be dry sanded with No. 180 paper. We recommend dry sanding as in wet sanding the putty is likely to become water-soaked and to show welts.

Having completed the priming operation, the job is ready for surfacer. This should be sufficient to cut down to a smooth surface when wet sanded with No. 280 paper and scuffed off with No. 320 paper to take out the scratches. At this stage it is necessary for the finishing operator to decide whether the surface he has built up is smooth and free from all imperfections, because pyroxylin finish will emphasize any marks in the undercoats, and surfacing plays a large part in obtaining a representative finish.

Moldings

Moldings have been a source of a great amount of trouble, not only to the refinishing shops but to the production plants as well. Our experience has been that

unusual care should be taken in applying the undercoats. It is advisable to work the putty well up to the molding, coming up close, laying a good coat and bearing in mind that the putty can be feathered down readily in the sanding. Some finishers have the mistaken idea that putty should not be run up to the molding, as they have attributed the breaking away from the molding to the putty. It is true that trouble will occur if sanding around molding is not done very carefully; in this connection, great precaution should be taken to see that all joints and moldings are clear and cut clean.

When two colors are to be used on an enclosed body, it is necessary to attach a paper mask around the molding by adhesive tape to protect the top and the body while spraying. Window glass should also be covered by attaching masks to the sash with tape. To begin, the pyroxylin enamel should be stirred well and boxed from can to can or, a device to agitate it thoroughly can be made, having a frame to hold a can firmly and rotating it on a shaft. Such a device is simple in construction and can be run by an idler pulley from the motor connected with the compressor. This agitation is important for all light shades, particularly greys. We have investigated many off-shade complaints, especially in touch-up work, and have found that the pyroxylin enamel was not properly stirred to obtain the true color.

Usually, our pyroxylin finish should be reduced with equal parts of our No. 3601 thinner. Some operators adjust the thinning according to their own liking. The first coat should be sprayed on very lightly and followed by the second coat in about 30 min. Some operators apply two light coats, one after the other, and get satisfaction; but we prefer the foregoing method as caution must be used, particularly in view of the fact that the job is now well under way and one cannot afford to have the excess solvents raise or blister the undercoats by applying too heavy a coat of the pyroxylin finish, which causes the solvents to penetrate the undercoats.

After the first two coats have dried thoroughly, the surface should be examined for imperfections. Two more coats can then be applied, one right after the other. The operator should judge how many coats he needs to complete the job, taking into consideration that he must have an opaque coating which will withstand the necessary rubbing without cutting through to the surfacer and which, after rubbing, will leave a film capable of withstanding future wear by friction. On closed jobs where two colors are used, the moldings can now be cut in, provided all the pyroxylin coats have dried thoroughly.

After the pyroxylin coats have been applied, allow the car to stand over night at a room temperature of 60 deg. fahr. If the spray work is very good and entirely free from spray waves, pebble effect and the like, it will only be necessary to rub and polish with a proper rubbing compound in accordance with the directions. However, if the spray work is not good, it can be bettered by rubbing with No. 400 paper and high-test gasoline, free from fixed oil or with a neutral soap-solution to prevent loading the paper, which will mar the surface. Clean up and spray on a mist or glaze coat consisting of 80 parts of No. 3601 thinner and 20 parts of pyroxylin finish by volume. Allow to harden off and rub and polish with a high-grade rubbing-compound.

Striping

Several striping colors may be used. One is made with Japan color reduced with No. 3601 thinner and mixed with body-finishing varnish; another is our pyroxylin finish thinned with No. 3942 retarder. Extraordinary care must be taken in using these striping materials, as they do not permit of any correction being made when they bite into the surface. Another striping can be made with a color ground in oil, reduced with turpentine and mixed with rubbing varnish. This stripe is far less durable than the other two and will be marred easily by the abrasive action in cleaning the car. In fact, we have seen stripes of paint material entirely removed by cleaning and recommend that, if at all possible, pyroxylin finish be used for striping. It is absolutely necessary that the striper work with a full brush.

Upholstery can be cleaned with a vacuum cleaner. On open cars, the top should receive a coat of dressing. All nickel parts should be renickeled. The car is now ready to assemble. In this connection, none other than a thoroughly experienced mechanic should dismantle a car. He should identify each part with a metal tag, so that, when it is delivered to the owner, it will be in order after being assembled. Neglect or carelessness in these operations often causes great inconvenience.

THE DISCUSSION

A MEMBER:—What average time is required to apply pyroxylin finish on a car that already has been painted, first removing the paint?

C. E. PETERSON[3]:—It depends somewhat on conditions. A man who is familiar with his work can do the biggest job in 10 days. Conditions in shops differ at times; for instance, if the workman can work without any interruption he can finish the job in 10 days, but if he stops from time to time to work on other cars it requires from 15 to 16 days.

A MEMBER:—In our repainting jobs, we even find it unnecessary to remove the fenders. Could you guarantee the work for a period of 18 months?

J. J. RILEY:—In repainting, it is necessary to remove any parts that will interfere with the finishing. If the system is followed, the finish will be good for that time and longer.

W. L. LE PAGE:—I understand that Mr. Riley's company has devoted its attention to developing a polished pyroxylin finish to meet the demand of those who prefer something more than the usual varnish. That, I understand, is applied by hand. Since the amount of energy put into this work must be considerable, how does this system work out around parts of the car such as the door handles and window frames?

MR. RILEY:—We have a complete polishing specification. The rubbing-compound used in the application of this system contains abrasive material that will buff the finish down to a light reflecting surface. Attention to the application of undercoats plays a large part in obtaining a uniform polish; in other words, there must be a uniform surface for the final polish. This will work very well around handles, as the handles are removed, and around window frames, provided there is a sufficient film to polish without rubbing through. The details in which these two particular parts are included should be given care.

A MEMBER:—What is the cost of a first-class varnish job of the old-class system, compared with the pyroxylin job?

MR. PETERSON:—A refinished varnish job will be cheaper even if burnt off, as considerably more attention must be given to under-surfacing for pyroxylin enamels.

QUESTION:—How many coats are required for a polished pyroxylin-finish?

[3] Service man, chemical products division, E. I. du Pont de Nemours & Co., Inc., Parlin, N. J.

MR. PETERSON:—That varies with the condition of the car. When the surface is smooth, from three to five coats are required.

PROF. E. P. WARNER[2]:—What agency is the most destructive to pyroxylin finish; is it light, heat or cold? We find that light is the most destructive to the dope on airplane wings.

MR. PETERSON:—Friction is the most destructive agency.

M. R. WOLFARD:—How many coats is it necessary to put on?

MR. PETERSON:—The number of coats depends entirely upon the quality of the surface that the finisher has built up. The first coat should be sprayed on very lightly and followed by the second coat in about 30 min. One cannot afford to have the excess solvents raise or blister the undercoats by applying the pyroxylin too heavily. After the first two coats have dried, the surface should be examined; then, two more coats are put on one right after the other.

A MEMBER:—A painter who was doing some pyroxylin finish work in which two colors were being used had success with the grey color of the car but the black color did not stand up at all well. Why did it fail?

MR. RILEY:—I cannot understand this. Our black is comparable in durability to other shades. Possibly the painter might have applied the black to the fenders over the old finish and the pyroxylin finish did not have proper adhesion.

A MEMBER:—How many hours of labor do you consider a fair length of time to refinish a Packard sedan with pyroxylin enamel?

MR. PETERSON:—For a first-class job, it would take from 115 to 125 man-hours of labor provided the men were qualified in the application of the system.

R. D. STONE:—If a coat of varnish were put on top of a pyroxylin-finished job, would that varnish stick to the pyroxylin finish?

MR. RILEY:—From our experience, varnish will not knit to a pyroxylin-enamel film.

QUESTION:—Is it necessary to take the nickeled parts off?

MR. PETERSON:—All nickeled parts should be taken off and renickeled for a first-class job.

A MEMBER:—What would the total cost be of pyroxylin-finish job on a Packard sedan?

MR. PETERSON:—In one case a pyroxylin job was done on a Cadillac suburban for $300; it represented 142 hr. of labor. The foreman thought that was too much time.

[2] M.S.A.E.—Professor of aeronautical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

ENGINE LUBRICATION

THE connecting-rod big-end bearings of internal-combustion engines rely almost entirely on the oil circulation through them to carry away the heat generated, and at very high speeds it is necessary to circulate a very large quantity of oil, many hundred times greater than that required to maintain and replenish the oil-film, for the purpose of carrying away the heat generated. Although familiar with the design of a steam locomotive, it may not have occurred to many automobile engineers how extraordinarily severe is the load factor on the connecting-rod big-end bearings of a locomotive. These bearings are lubricated in a very haphazard and stingy manner, yet they very seldom fail, although the load factor on them is considerably greater than is possible in any enclosed high-speed internal-combustion engine. The explanation is that, being fully exposed, they are very efficiently air-cooled. If the working parts of a locomotive were enclosed in an oil bath, the bearings would fail in a very few minutes, unless an enormous quantity of oil were circulated through them and a very efficient oil-cooler provided.

In very high-speed engines one is faced with the difficulty that, if enough oil be forced through the big-end bearings to carry away their heat, the amount flung out to the cylinder-walls will be excessive. In such cases it is preferable to make the crankshaft hollow and maintain a very rapid circulation through it from end to end to cool the crankpins internally, allowing only a small proportion to escape out of the big-end bearings.

I have not yet been able to discover that one metal has less friction than another under the normal conditions of flood lubrication. The great virtue of white metal lies in two properties that it possesses. First, its surface is very soft, and, secondly, and perhaps even more important, its melting-point is below the boiling-point of the lubricant, so that in the event of local metallic contact occurring, due to some accidental cause, the white metal will fuse locally without boiling off the oil and so allow the oil-film to recover, when it will readjust itself and solidify. Evidence that this happens frequently in white-metalled bearings, generally over a minute area at a time, is available.

It is frequently noticed that in high-speed engines, especially with forced lubrication, the main crankshaft bearings wear relatively quickly but never fail so long as they are lubricated, while the big-end bearings sometimes fail outright but show very little wear. The explanation is, of course, that the main bearings can get rid of their heat readily enough and so do not fail, while the big-end bearings have little heat capacity and very little opportunity for conducting heat away; hence they are liable to fail from overheating. On the other hand, with forced lubrication, the oil supplied to the big-end bearings has first passed through the best of all filters, namely, the main bearings, and most of the grit has already been intercepted so that very little reaches the big ends to cause wear.

In the case of the piston-rings the lubrication is probably of the boundary type and the coefficient of friction some 10 times greater. In the case of the piston itself, the conditions of lubrication appear to be somewhere between flood and boundary lubrication. Here the amount of heat generated does not matter, for the piston has to be competent to deal with much more heat than that generated by friction, but the friction as such does matter very considerably, because it is so large. To keep down viscous friction, the area of rubbing surface must be reduced as far as possible, and all unnecessary bearing surfaces at the sides eliminated. To keep down the greasy friction, the side-thrust must be reduced, which means, in effect, that the weight of the piston must be reduced so far as possible, for the bulk of the average side-thrust is due to the resolved inertia forces.—H. R. Ricardo in *Automobile Engineer.*

Power Take-Off for Tractors

By F. N. G. KRANICH[1]

TRACTOR MEETING PAPER *Illustrated with* PHOTOGRAPHS AHD CHARTS

ABSTRACT

VARIOUS attempts have been made to obtain power from tractors for operating attachments. In some cases the power has been supplied by an engine mounted on a separate truck. Modern applications of this principle of power transmittal differ from previous ones in that the drawn machine, instead of getting its power from a bull-wheel through its contact with the soil, receives it directly from the tractor engine through a tumbling-rod or flexible shaft. Mechanisms operating through a bull-wheel, the speed of which is regulated by the rate of travel, proved very inefficient, for the efficiency varied with the lug arrangement on the wheels and with the nature of the soil.

To meet the demand for a separate power-unit, internal-combustion engines in one and two-cylinder sizes of from 3 to 10 hp. were commonly attached to machines drawn by other means. The engines furnished the machines with a constant speed regardless of the rate of travel. Combined tractors and harvesters were among the first machines to be thus equipped.

Power take-offs are divided into two types: (*a*) those in which the speed varies with and is a function of the rate of travel of the tractor and (*b*) those in which the speed is constant, being directly a function of the engine speed and independent of the rate of travel. The advantages of the latter lie in the fact that it is frequently necessary to maintain the speed of the attachment while working under conditions that render low speed of the tractor desirable or obligatory.

As the mechanical features involved in the various power take-offs now in use differ greatly with regard to the location and the speed of the final driving-shaft, the method of transmitting power, the percentage of available engine power required, the types of slip-clutch and other safety devices, the means of changing the setting to increase or decrease the torque transmitted, the provision for turning corners, the use of universal-joints, the location of the power take-off to the right or left of the center-line of the tractor and the ease of coupling or uncoupling the attachments; an appeal is made for cooperation between the makers of tractors and the makers of implements in order that standards may be adopted and designs produced that will be acceptable to all persons concerned.

A POWER attachment is a means of transmitting power to a machine-unit that can be attached directly or coupled to and drawn by a tractor. A power attachment differs from a belt-pulley attachment, inasmuch as the latter is a tractor part for transmitting power to stationary machines by belting. An early application, differing radically from the present one, was in use on the Pacific coast about 1904 in connection with a combined harvester and steam tractor. Similarly to the present custom, an engine was mounted on the harvester but received its power through a hose from a steam-boiler mounted on the tractor by which the harvester was drawn. This without doubt was a power take-off.

Some of the early steam-plowing outfits that used to break the virgin prairies of the Northwest were frequently used with a steam plow-lifting device. Here too the tractor furnished the power.

Some of the early steam-engines used for hauling at mines and gravel-pits or in the timber districts were supplied with winches carrying drag-lines. The tractor was usually run ahead for about 200 ft. with a line attached to the units to be drawn. The tractor was then blocked and the power was applied directly to the winches to bring the load to the tractor; after which it was again coupled to the drawbar when the going was easier. The winches were driven from the belt-pulley of the engine, or from the crankshaft, by belts or chains and sometimes by bevel gears. Cable plowing may also be termed a means of applying a power take-off.

About 1909, a builder of stationary gas-engines mounted them on a separate truck coupled to a grain-binder. The mechanism of the binder, which was horse-drawn, was driven by a chain.

MODERN APPLICATIONS

Modern applications are different. Instead of the drawn machine receiving its power from a bull-wheel through its contact with the soil, it gets it directly through a tumbling-rod or flexible shaft from the tractor engine. As these implements were originally developed for animal-drawn units, this method was logical. In fact, even machines as large as combined harvesters, including not only a 12 or 16-in. cutting-mechanism but a complete threshing-machine, were run from power developed through the bull-wheel and its contact with the soil. This method, however, proved very inefficient and has been almost entirely abandoned.

In all such cases, in which the mechanism operates through a bull-wheel, the speeds are regulated by the rate of travel. The lug arrangement on the wheel and the kind of soil determine the efficiency. This means that the speed is based on a positive drive, in other words, 100 per cent tractor efficiency. As the soil varies, which it does, slippage is apparent, becoming in some cases as much as 12, 15 or 20 per cent. In the rice country, or during the rainy season, it is sometimes impossible to get any traction whatever.

These facts in the early days having brought about a demand for a separate power-unit, the internal-combustion engine, in one and two-cylinder sizes of from 3 to 10 hp., became a very common attachment to machines drawn either by horses or by tractors, in places where it was difficult to get proper footing for successfully operating the machine through bull-wheel drives. In these cases, the engines furnished the machines with constant speed, regardless of the rate of travel. They were geared up or down, as the case might be, to obtain a speed a little in advance of that calculated to suit the fastest rate of travel with the tractor. As the speed or rate of travel of the tractor was reduced, therefore, no effect was produced in the operating-mechanism of the drawn machine.

Combined tractors and harvesters were among the

[1] M.S.A.E.—District manager, tractor and implement division, Timken Roller Bearing Co., Chicago.

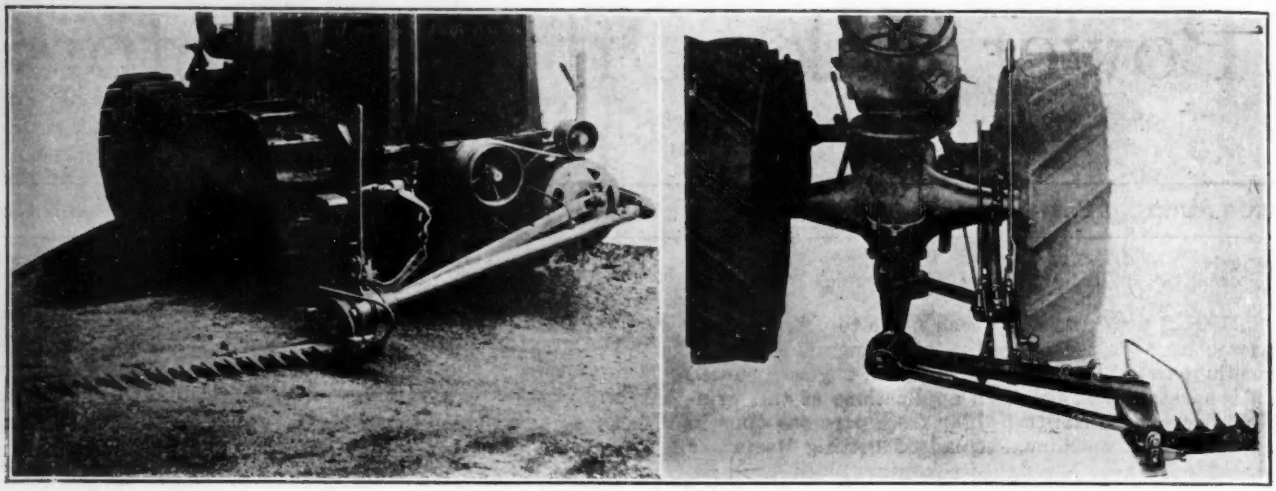

FIG. 1—TYPES OF POWER TAKE-OFFS
At the Left Is Shown a Mower Sickle-Bar Operating at Constant Speed as a Function of the Speed of the Engine of the Tractor; at the Right, a Sickle-Bar Operated through Gearing and Dependent on the Speed of the Tractor

first machines to be regularly provided with engines for furnishing the power. In these cases, the units were sometimes of 40 or 50 hp.

TYPES OF POWER TAKE-OFF

Two distinct features found in power take-offs divide them into two classes or types, as is shown in Fig. 1. These are well illustrated in mowing attachments, which, although not drawn behind a tractor through a drawbar, because the units are small, nevertheless are attached to it. This explanation will serve to illustrate a point: In one case, the mower cutting-mechanism, or sickle-bar, is operated by a transmission gear-mechanism, or from the belt-pulley shaft of a tractor; in the other case, the sickle-bar is operated from one of the rear driving-shafts of the tractor. The former, shown at the left, has a constant speed, regardless of the rate of travel of the tractor, which is directly a function of the engine speed; the latter, shown at the right, a speed that varies with and is a function of the rate of travel.

Engineers vary in their opinions as to which is better. No fixed rule can be laid down, since this will always be a matter of opinion. Some advantages, however, lie in the use of the former type. These are well illustrated in such conditions as are encountered in the rice country, where the stands of grain are heavy and the traction is poor. This allows the tractor to be put into low gear, yet the speed of the rice-binder can be maintained sufficiently high to do the work that may be required, without unnecessarily crowding it and causing frequent breakages and delays. Even machines used for digging potatoes or for harvesting grain, whether it be wheat or corn, will work better when operated at a uniform speed. On the other hand, because of soil conditions, a relatively low speed of the tractor may be desirable.

FIG. 2—POWER TAKE-OFF REQUIRING NO UNIVERSAL-JOINTS
The Location of the Final Driving-Shaft Varies Almost as Much as Do the Makes of Tractor

HARVESTING IN HILLY COUNTRY

In cutting grain or harvesting any crop on land that is hilly, where the load on the tractor may be seriously increased by the grade, this feature will allow dropping into low gear and will materially aid in overcoming the difficulty, while at the same time performing work that is important to the farmer at that particular time. Grain that is lodged and down, whether it be small grain or corn, often calls for a slow rate of travel and, at the same time, a relatively constant speed of the harvester. Heavy stands of grain may bring about the same condition.

In making calculations of speed, it should be borne in mind that no lag on the part of the harvester shall occur when the tractor is in high gear; this would be serious. It would be equivalent to taking power from the bull-wheel, when insufficient traction is found, and will cause slippage. This would mean plugging of the harvesting machinery and, in addition, at reduced speeds, building-up heavy loads far in excess of those for which the mechanism has been designed and constructed. It should be the aim, therefore, of all agricultural engineers to design the power take-off so that the speed in high gear will always be in excess, though it may be only a trifle, and that no lag or drag of any sort will occur at any time.

Most tractors have, in fact all should have, governors that will establish a constant speed and a figure for high gear on which calculations can be based. Some good attachments have proved unsuccessful because this factor has been overlooked.

DIFFERENCE IN MECHANICAL FEATURES

The mechanical features involved in the various power take-offs differ greatly. Some, it may be said, served merely to bridge a gap for the time being; others were incidental to the design of the tractor and probably happened to fall into a certain place at a certain speed. The

location of the final driving-shaft, therefore, varies almost as much as do the makes of tractor. A power take-off applied to a tractor and requiring no universal-joints is shown in Fig. 2.

When a manufacturer sometimes builds two or three machines provided with power take-offs, the location and the speed of the final driving-shaft are not the same on any two. This is accounted for by differences in the size of the units and in the heights and widths of the tractors.

Some attachments are driven by belts from the driving-pulley, some by chains from the driving-pulley shaft; some have enclosed, some open transmissions; some are driven from transmission gears on top of the tractor, some from those on the bottom; some on the right, others on the left side, wherever the engineer finds it most convenient to attach them with the least expense. The point at the rear of the tractor from which the power is taken off consequently varies in like manner.

Various attachments have been made and are being marketed that provide for supplying from 25 to 100 per cent of the engine power through the power take-off. This is a factor that should receive consideration by engineers, with a view to determining what is logical, because it will afford a means of making calculations in establishing the sizes of drive-shafts for transferring the torque in the best possible manner.

Percentage of Power to Be Taken

In no case should it be possible to take power from the engine in excess of that which might be required to propel the tractor and to draw the machine, for doing so would defeat the original purpose that it was desired to accomplish. Many engineers conclude that only 50 per cent of the engine's power is required; on the other hand, when the tractor is standing still and power is to be transmitted to a drawn unit, it is likely that more power will be available. But is it necessary? All these things must be settled because manufacturers in building the units to be drawn are seriously handicapped by not knowing all the facts in the case when making the designs.

A manufacturer recently stated that he was ready to adapt his line to power take-off attachments suitable for tractors, but that owing to the chaos existing in the tractor industry with reference to developing these attachments, he was unable to proceed. He could develop parts suitable for particular makes of tractor but it was not good policy to do this and should not be necessary, because it is logical and easy for engineers to cooperate and standardize these parts.

Slip-clutches or safety devices of various types have been introduced on the power take-off driving-shaft between the tractor and the drawn machine. These slip or safety devices are made with means for adapting them to the power required, but they are not marked in any way so that a farmer can attach them to a particular point that will give him a fixed amount of power output. The need of such devices is apparent. The value of the different makes of tractor now used varies with the attachments. It is likely that some unit will be employed which will be applicable for use on the various machines and will be satisfactory for them all. Whether a means of changing the setting to increase or to decrease the torque transmitted is logical is a question that must be decided. If it is logical, what should the figures be? How much should they vary? To what machines are they best suited? What is good for one machine may not be good for another. Some power take-off shafts are provided with a telescoping joint to suit the ever-varying distance between the tractor and the drawn implement, both when running straightaway and on the turns. Different machines may call for different distances.

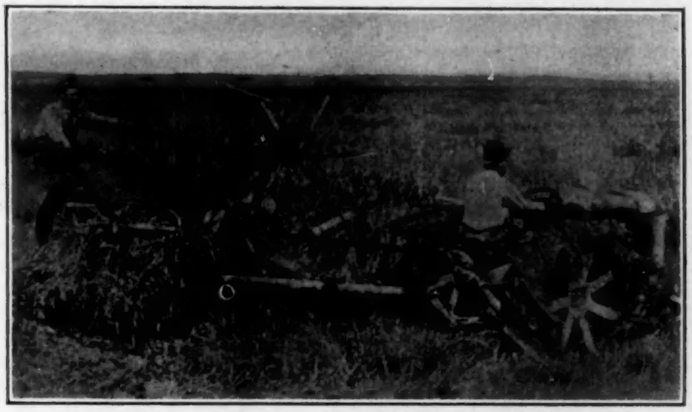

Fig. 3—Power Take-Off Applied to a Grain-Binder
Being Equipped with Constant-Speed Gears and No Universal-Joints, This Attachment Allows Corners To Be Turned While Almost Constant Speed of the Power Driving-Mechanism Is Maintained

Interference in Turning

The various attachments sometimes interfere rather seriously with the turning of the tractor. Some tractors have facilities for turning very short, in fact, at right-angles and in their own length; some are provided with means even for turning on their own centers. A power take-off, to fit into the scheme of things, should, therefore, provide at least for turning square corners, such as occur when harvesting grain, very often hay, even corn or in fact any crop in a small area.

The use of a number of universal-joints may bring about a condition on the turns that is not good for the implement doing the work. Universal-joints have their limitations. Power take-off attachments that provide for square turning and that overcome universal-joint objections have been designed and are on the market. Such attachments allow corners to be turned while

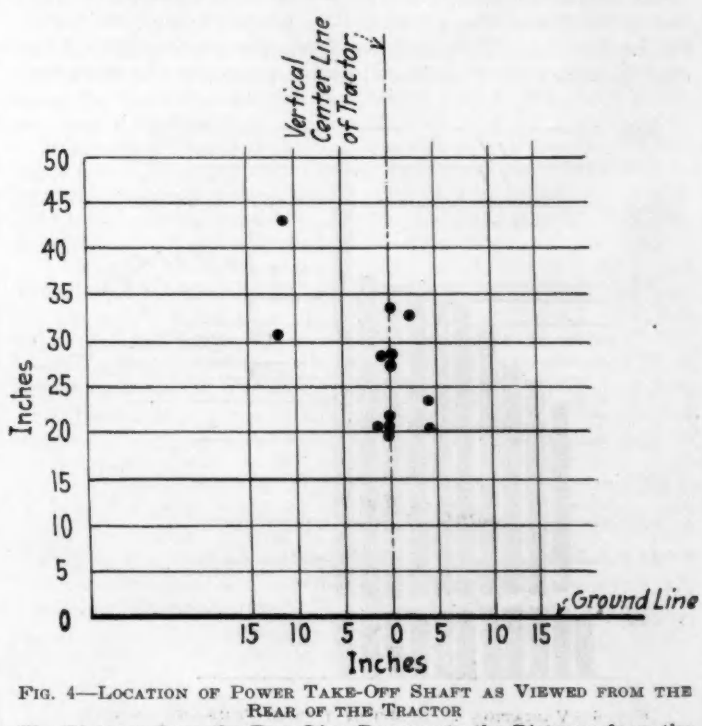

Fig. 4—Location of Power Take-Off Shaft as Viewed from the Rear of the Tractor
The Distance from the Base-Line Represents the Distance from the Ground; the Vertical Line Represents the Center of the Tractor

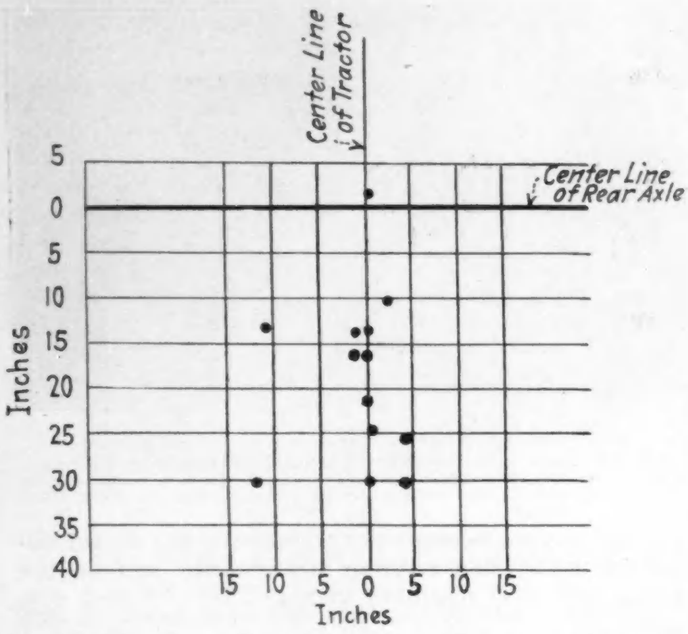

FIG. 5—LOCATION OF POWER TAKE-OFF SHAFT AS VIEWED FROM ABOVE
The Distances from the Center-Line of the Tractor and from the Center-Line of the Rear Axle Are Indicated

almost a constant speed of the power driving-mechanism is maintained. One of these is shown in Fig. 3. Some of these attachments provide a constant speed regardless of the angle at which the drawn machine sits. Then, too, it is apparent that if the point of attaching the power take-off is set either to the right or to the left of the center-line of the tractor, it will seriously interfere with turning to the right or to the left of the drawn machine. Some are even made with which turning to the left is not advisable; some, with which turning to the right is not desirable.

Fig. 4 illustrates the location of the power take-off shaft as viewed from the rear of the tractor, the distance from the base-line representing the distance from the ground and the vertical line representing the center of the tractor. The distance from the center-line of the axle is shown in Fig. 5 and gives a clew to the turning-

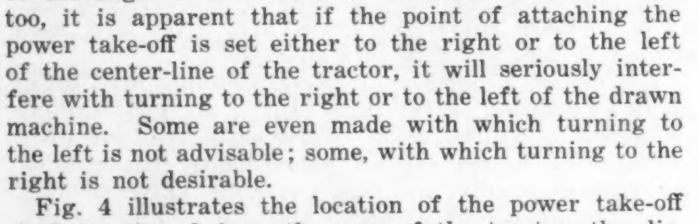

FIG. 6—VARIATION IN SPEED OF POWER TAKE-OFF SHAFTS
The Speeds of Various Attachments Are Compared with the S.A.E. Standard of 536 R.P.M

radius and also to the leeway that must be provided on the shafting running back to the drawn machine. The center-line of the tractor drawbar should have been shown but, as it complicated the diagram, it was omitted. Fig. 6 illustrates the variations in the speed of attachments, that is, the speed of the so-called power take-off shaft on the tractor itself.

All these are factors that the engineer who designs the binder, the mower, the spraying-machine, the corn-binder or any other machine that receives its power from this attachment must overcome. The various units may be sold with any tractor or may be sold to a farmer having any of the various tractors. A farmer may even use some particular make of tractor with any of the variously drawn machines to which he proposes to supply power with a power take-off.

ATTACHMENTS MAY DEFEAT THEIR PURPOSE

An attachment is designed to simplify the farmer's problems and make them easier, yet, due to the factors mentioned above, the result may be the reverse. In such a case an attachment would serve as a handicap and might even tend to defer the day of the more common use of a very important attachment or tractor part. It is really important and affords an economic means not only of increasing the tractor's usefulness, in causing it to be used more days in a year, but primarily in facilitating the harvesting of the crop at the right time in the quickest and best possible manner and with the least expense.

The farmer's schedule includes the time that must be devoted to plowing, discing, harrowing and smoothing the land. Added to these is the time required to plant and perhaps to cultivate the crop, which is often one of considerable importance. In some cases, the crops must be sprayed. Finally, when harvesting time approaches, all the work previously done may be jeopardized by his not being able to harvest the crop at the proper time. This is really the place where a farmer "cashes in" on all his previous work and, regardless of how well all the other operations have been performed, regardless of how good a yield the crop may promise, if the harvesting is not done efficiently and at the right time, the losses may be so great that they may be a serious handicap and may mean the difference between profit and loss in the final accounting.

Among the machines that may be logically fitted for operation with a power take-off from the tractor are grain, rice and corn binders, shockers, hemp harvesters, corn pickers, field silage harvesters, potato diggers, mowers, combined harvesters and orchard and field spraying-machines. In talking with agricultural engineers in charge of or responsible for the design of grain-drills, where it might seem logical to use the power take-off, it was learned that so far these have not afforded even a means of or a field for research work in this line. The same is true of manure-spreaders, in which power is taken from the bull-wheel. Although some experimental work has been done, nothing as yet has been produced that seems to afford more economical operation with machines of this sort. Rotary plows of various types and kinds have been developed in which power from the tractors produces the rotative speed of the tilling units. That these units will ultimately be operated from the power take-off unit, however, is likely.

The ease with which the various attachments can be coupled and uncoupled is an item worth consideration. It must be very easy and very simple to bring about a general use of an attachment. If this is done, the eco-

nomic value, of course, cannot be and never will be disputed, for the farmer is about as quick to recognize the value of attachments as are the manufacturers to design and build them. In some cases, the farmers are even a jump or two ahead and are asking for modern equipment in advance of its development.

Safety is an item not to be neglected. Take-off shafts with their several joints, if at all dangerous, must be made safe.

CONCLUSIONS

In conclusion, a few things should be given serious consideration with a view to getting attachments into more general use, because they are of value to the farmer and have a distinct place in tractor operation. These are

(1) Speed
(2) Attachment to tractor
(3) Height
(4) Horizontal location
(5) Location with reference to drawbar
(6) Slip-joint

Whether it is possible to determine definitely the standard speed of attachments to suit the various machines that they must drive is still a question. A standard has been adopted but some manufacturers find it difficult to use it without a gearbox that will necessitate either a speeding-up or a slowing-down to suit the machines that they make.

The means of attaching the power take-off to the tractor is not the same on all makes. As it will probably fall to the lot of the manufacturer of the drawn machine to supply the power take-off attachment, it would seem that a fixed kind of attachment should be adopted that will be the same for all makes and be easy to attach and to remove.

The height of the power take-off shaft on the tractor and the distance between the drawn machine and the tractor vary. Telescoping joints of some sort are necessary. Should not this height be standardized?

The most desirable and the most practical place for locating the power take-off horizontally should be given consideration.

Whether the power take-off be located on or at the extreme rear end of the tractor will depend on whether the diameter of the driving-wheels or the wheel guards interferes with turning.

Whether the slip-joint be on the driving-shaft or on the tractor and the percentage of power to be transmitted by the friction-slip device should also receive some consideration.

Since these attachments are now in the making, it appears that this is the right time to bring them to the attention of both the manufacturers of tractors and the manufacturers of implements that are to be used. It is no doubt possible to produce designs that will be acceptable to all concerned. This can be done best by close cooperation between the various organizations, perhaps through an engineering society, which may serve as a medium for standardizing the things that will bring the greatest good to the greatest number.

Since no question exists as to the economic value of the power take-off attachment, surely there never was a time for doing a thing more nearly right than when it is in its embryonic state. It will not occur of its own accord. Two or three manufacturers must assume responsibility for the work; and nothing worthwhile in any line of endeavor has ever resulted without effort. No standards have been adopted, no units of value that have been of benefit to both the manufacturer and the farmer have ever been developed without work on the part of some person or persons who have made an earnest and sincere endeavor to do things because they were a contribution to an important economic industry. Of such an industry we all are a part.

MECHANICAL LOSSES IN ENGINES

THE mechanical losses in engines remain practically constant, irrespective of the torque, for though the friction increases slightly with an increase of load, the work done in filling the cylinder increases as the throttle is closed and the two practically balance. An 80-per cent mechanical efficiency at full load becomes only a 55-per cent efficiency at 30 per cent of full torque, while a 90-per cent mechanical efficiency becomes 73 per cent, so that the difference that has to be taken into account is not that between 80 and 90 per cent, but rather that between 55 and 73 per cent, a much more serious matter.

Of the gross mechanical losses, piston friction in a well-designed engine accounts, as a general rule, for about 60-per cent of the total. Pumping losses account for about 25-per cent, while the friction of the bearings and all the auxiliary gear amounts to about 15-per cent.

Piston friction can best be attacked by keeping both the weight and the bearing surface of the piston down to the minimum. Pumping losses are not susceptible of much reduction. A little can be done by the use of large valves and the most suitable timing, but on reduced loads the losses are mainly due to the restriction through the partially closed throttle. These losses are, therefore, more or less inevitable unless means can be found to work with a weakened instead of a throttled mixture. Moreover, unless means be adopted to augment turbulence during the compression, the valves must be kept fairly small, and the velocity through them high, or slow and incomplete combustion with loss of power and efficiency and excessive heat flow will result. The friction of the bearings is relatively small in any case but is none the less large enough to make it well worth while doing our best to reduce it.

It is almost impossible to assess the losses due to general vibration. However, an engine cannot vibrate without absorbing a considerable amount of energy in so doing. Every effort should be made to ensure the best possible balance on this account, as well as for other reasons.

Excessive turbulence gives rise to excessive heat-losses and a narrowing of the mixture range. It gives rise also to excessive roughness of running. Fortunately, the optimum degree of turbulence from the point of view of efficiency corresponds to a rate of pressure-rise of from 30 to 40 lb. per sq. in. per degree of crankshaft travel and does not involve so rapid a rate of pressure-rise as to be troublesome.

It is the rate of pressure-rise, and not the maximum pressure, which gives rise to harshness. That is to say, it is a question of turbulence, not of compression. A high-compression engine, so long as it is not detonating, will be fully as sweet-running as a low-compression one provided its rate of pressure-rise is the same or less.—H. R. Ricardo in *Automobile Engineer.*

Die-Castings Made of Non-Ferrous Metals

By MARC STERN[1]

DETROIT SECTION PAPER

Illustrated with PHOTOGRAPHS AND DRAWINGS

ABSTRACT

SUBSEQUENT to an historical review of die-casting, briefly stated, the author covers the subject of present die-casting practices comprehensively and conveys a large amount of specific information. Because many different methods of producing castings exist outside the sand-casting realm, he says that some confusion prevails as to the exact definition of the term "die-casting." Such castings may be produced in metallic or in non-metallic long-life molds, or in combination with destructible cores. They may be filled by gravity and known as "permanent-mold castings"; or by centrifugal force and known as "centrifugal castings"; or by filling the mold by gravity and, after the outer skin has become chilled, pouring out the excess metal. The last named are known as "slush castings." On the other hand, a die-casting may be defined as a casting formed in a metallic mold or die, from metal subjected to mechanical or gaseous pressure while in the molten state.

It is important to contrast this last definition with so-called "pressed castings" or drop-forgings in which the pressure is applied while the metal is in a plastic or a semi-plastic condition that makes impracticable the coring of side holes.

In die-castings, the metal being liquid, the pressure is practically uniform in all directions, and complicated coring of holes and of side cavities is therefore easy of accomplishment. The molten metal, coming into contact with the comparatively cold surfaces of the mold, chills immediately and the feed of the metal is maintained under full pressure until the die-casting has solidified completely. The sudden cooling forms a smooth, hard skin on the surface, with a comparatively coarser structure at the center of the walls.

Alloys of comparatively low fusing-points, best adapted to the die-casting process, are divided into groups and their characteristics are stated. The design of die-castings is covered, and the paper treats also of the polishing, enameling and electroplating of die-castings, the methods used for die-castings and the applications and limitations of die-castings in general.

THE art of casting metals into previously prepared molds has been known and practiced since prehistoric times. The casting of metals is referred to in many passages of the Bible, the most prominent being that of the casting of the golden calf. An entire series of molds belonging to the first dynasty of Egypt, about 2400 B. C., has been unearthed. It shows that the molds were carved in thick pieces of clay, baked into pottery and lined with a fine ashy clay. In the lake dwellings of Switzerland, various molds have been found dating from 1000 to 2000 B. C., made either of rock or of clay. Rock seems to have been preferred for the flatter objects, and clay for the more complicated castings. These molds were made of two or more parts, suitably dowelled, so that they could be joined. Casting in sand molds started on a commercial scale in England at the beginning of the Eighteenth Century. The first appearance of the metal molds seems to have come with the advent of printing during the middle part of the Fifteenth Century, and has reached its highest state of development in the modern monotype and linotype machines. This brief historical review is made to show that the casting of metal in molds which may be used again and again and which is the basis of the art of die-castings, is really the forerunner of the sand-casting process.

Die-casting, as it is known today, is a comparatively recent art in its commercial applications. It developed with the growth of large-production methods in the manufacture of interchangeable parts. Die-castings were first applied to such devices as cash registers and phonographs, and it was not until 1904 that they were applied in the form of bearings for automobiles. Rapid growth of the automobile industry served as a stimulus for the study and development of aluminum die-castings, which made their first appearance in 1914. Today, about 75 per cent of the productive capacity of the die-casting industry is devoted to the manufacture of parts for automobiles and their accessories, in such forms as speedometers, magnetos, oil-pumps, lighting systems, spark and throttle levers and body hardware.

Some confusion still exists as to the exact definition of the term "die-casting," because of the many different methods of producing castings that exist outside the sand-casting field. Die-castings can be produced in metallic or in non-metallic long-life molds, or in combination with destructible cores. They can be filled by gravity, being known as "permanent-mold castings"; by centrifugal force and known as "centrifugal castings"; or by filling the mold by gravity and, after the outer skin is chilled, pouring out the excess liquid metal, then being known as "slush castings." A die-casting is defined as one formed in a metallic mold or die from metal subjected to mechanical or gaseous pressure while in the molten state. It is important to contrast this definition with so-called "pressed castings" or drop forgings where the pressure is applied while the metal is in a plastic or semi-plastic condition, making impracticable the coring of side holes. In die-castings, the metal being liquid, the pressure is practically uniform in all directions, and complicated coring of holes and side cavities therefore is accomplished easily. The molten metal, coming into contact with the comparatively cold surfaces of the mold, chills immediately and the feed of the metal is maintained under full pressure until the die-casting has solidified completely. The sudden cooling forms a smooth hard skin on the surface, with comparatively coarser structure at the center of the walls.

Die-casting can be subdivided into low-pressure castings, in which the molten metal is subjected to pressures of several ounces up to 25 lb. per sq. in., and high-pressure castings varying from 50 to 1000 lb. per sq. in. The low-pressure method produces a dense internal structure with a tendency toward imperfections on the surface, due

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to uneven shrinkage. This process is limited to designs of a comparatively simple nature. High-pressure die-castings have a broader field of application, this paper being confined in its treatment to this type of die-castings.

Porosity of Die-Castings

Porosity is an inherent feature of commercial high-pressure die-castings. At first it was believed that porosity is due to the presence of air. The vacuum process was introduced so that the air was drawn out of the die-cavity before the metal entered. Even if it were possible to maintain a vacuum under practical working conditions, this method does not offer the complete remedy. Practically the same results can be obtained without a vacuum if the proper size and location of the gate and vent grooves are considered carefully.

Two other causes for porosity are uneven chilling of the metal and drossy or sluggish metal. To illustrate the first cause, consider a die-casting gated so that the metal must travel through a thin section to reach a heavy boss. Normally, the boss will solidify last; but, since the thin section between it and the gate is already frozen, it has nothing to draw from to satisfy its natural shrinkage and the difference is made up by a void or hole in the center. This emphasizes the importance of proper distribution of water channels in the die. The second cause is self evident, for a die-casting cannot have a cleaner structure than the original alloy. If the alloy becomes contaminated with too many impurities, its flow becomes sluggish and it chills before the shrinkage is satisfied, even in uniform walls. However, the outer crust is so much greater in density and strength that it more than compensates for the porous structure in the center of the wall.

An interesting illustration of how air becomes trapped in a die-casting is shown in Fig. 1. It represents a solid cylinder of 2 in. outside diameter, ½ in. inside diameter and 1½ in. high, with the gate at the bottom. The metal was forced under comparatively low pressure into a cold die so that the metal chilled before the impression filled completely. It clearly shows the flow-lines and the tendency to cling to the surface of the die. The way is shown in which the casting solidified at the top and prevented the escape of air. This is an exaggerated condition, because die-castings usually do not have such heavy walls

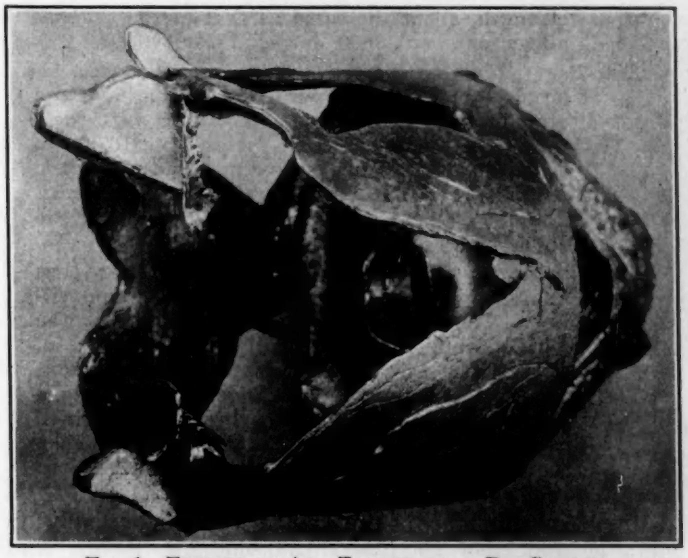

Fig. 1—Effects of Air, Trapped in a Die-Casting

The View Illustrates a Solid Cylinder Having the Gate at the Bottom and the Air Vents at the Top. The Metal Was Forced under Comparatively Low Pressure into a Cold Die So That the Metal Chilled before the Impression Filled Completely. The Flow Lines and the Tendency To Cling to the Surface of the Die Are Shown and the Manner in Which the Casting Solidified at the Top and Prevented the Escape of Air Is Indicated

and the running condition of the die was abnormal. However, it indicates the tendency toward porosity.

Die-Casting Alloys

The die-casting process is adapted best to alloys of comparatively low fusing-points and can be subdivided into the following four groups:

Tin-Base Alloys.—Contain 60 to 90 per cent of tin, 3 to 7 per cent of copper and 3 to 7 per cent of antimony. Alloys having the lower tin-content contain 10 to 25 per cent of lead. The maximum fusing-point is at 450 deg. fahr.; the tensile-strength, about 8000 lb. per sq. in. These alloys produce castings of fine sharpness and finish, but the high cost of tin largely limits their use

Lead-Base Alloys.—Contain 80 to 95 per cent lead, alloyed with antimony alone or in combination with tin up to about 10 per cent. The maximum fusing-point is 600 deg. fahr.; the tensile-

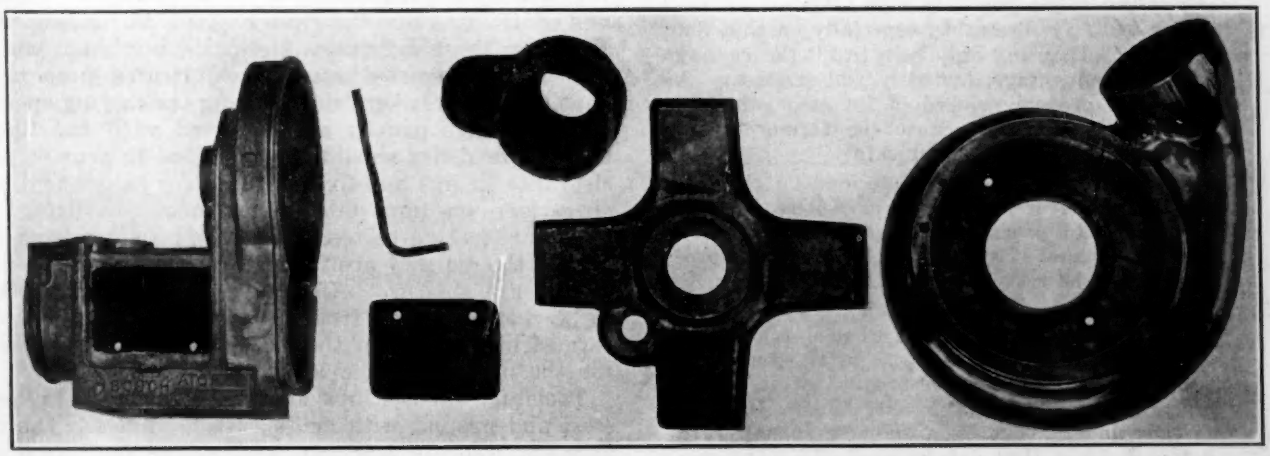

Fig. 2—Magneto Housing, Steering-Wheel Hub and Fan Housing, All Die-Cast

The Inserts Used in the Magneto Housing Are Shown Separately; the Tube Is Cast in Place To Lead Lubricating Oil to an Inaccessible Spot in the Assembly; and the Two Holes in the Pole Pieces Are Used for Locating in the Die. The Steering-Wheel Hub, of Aluminum, Is Cast Over the Insert Shown, Which Consists of Two Stampings of Hardened Steel. The Object Sought Is To Produce an Inaccessible Undercut, and a Strong Protection against Tampering with the Lock, Mounted within It. The Fan Housing Shows Clearly the Fins Left by the Seven Sections of the Center Core, Which Are Removed Separately To Make Possible the Casting of the Undercut

strength, about the same as that of the tin-base alloys, or about 8000 lb. per sq. in.

Zinc-Base Alloys.—Contain 88 to 95 per cent zinc, alloyed with tin and copper or with aluminum and copper. The fusing-point is about 780 deg. fahr.; the tensile-strength varies from 16,000 to 35,000 lb. per sq. in., depending upon the grade and the relative proportion of the elements. They resemble cast iron, being hard and brittle under blows

Aluminum-Base Alloys.—Contain about 90 per cent aluminum, alloyed with copper, nickel and silicon. The fusing point is 1150 deg. fahr.; the tensile-strength, 18,000 to 21,000 lb. per sq. in. Despite the fact that aluminum alloys present difficulties in handling, such as high shrinkage and a great affinity for ferrous metal, of which pots and dies necessarily must be made, they are the only high-melting-point alloys to achieve commercial success

Brass castings are being produced commercially in metallic and also in plastic non-metallic molds, and closely resemble die-castings in appearance, surface finish and accuracy.

Designing the Casting

No specific rules can be laid down to govern the design of die-castings, since frequently a design, which ordinarily might be considered impracticable, can be produced by special methods as illustrated by the castings shown in Figs. 1, 2, 3 and 4. It also is possible, by slight modifications in design, to apply standard casting methods without impairing the function of the part. Best results are obtained when the designer of a new device requiring die-castings consults specialists in this line, when the entire design is still on paper. The functional as well as the casting production-features can then be coordinated properly.

The observance of the following general rules should produce durable and economical designs:

(1) Avoid undercuts that make a core impossible to withdraw unless it is made up in sections. This is of no consequence in sand-foundry practice, because the core is destroyed with each casting

(2) Avoid sharp corners. It is more important than in sand castings because the rapid chilling of the metal and the unyielding consistency of the mold are likely to set up a strained section. Therefore, fillets should be used freely

(3) Ribs or webs are desirable, especially on thin flat surfaces. They not only help to fill the casting to better advantage, but they add strength. A thin wall properly ribbed is far stronger than a plain thick wall, because the former has a larger area of chilled outer skin

(4) Raised engraving should be specified on the die-casting whenever possible, because it is the most economical to produce. It can be placed on a depressed panel if the engraving must not project above the rest of the surface

(5) External or internal threads can be die-cast, but an extremely fine pitch of thread should be avoided. Internal threads, as a rule, are not practicable for aluminum because of its dragging tendency and high shrinkage. Internal threads under about ¾-in. diameter usually are not cast, since they can be produced more economically by tapping

(6) Spur gears or bevel gears with straight or spiral teeth are die-cast for light service. Whenever possible, a shroud should be added on one side

(7) Bushings can be die-cast with straight or spiral oil-grooves, but they preferably should be made to run out at one end

(8) Inserts should be used when greater strength, hardness or bearing qualities are needed at localized points of a die-casting. They also are used to reduce the cost of assembly, to provide lubricating channels to inaccessible points or to supply magnetic qualities, such as pole-pieces in magneto housings

(9) Wall thickness can be reduced as low as 1/32 in. for tin and lead alloys, 3/64 in. for zinc alloys and 1/16 in. for aluminum alloys over small areas. For large surfaces the wall thickness should be at least 1/32 in. greater

(10) Minimum diameters for shallow holes can be cast as small as 1/64 in. for lead and tin alloys, 1/32 in. for zinc alloys, and 3/64 in. for aluminum alloys

Accuracy of Die-Castings

Accuracy of a die-casting depends upon the wear of the die and the shrinkage of the alloy. The latter varies with the temperature of the molten metal, the temperature of the die and the time element required in ejecting the casting. Dimensions formed by slides or the parting line of the die, will vary more than those formed in a solid block. Even with all these variables the tolerances are better than can be secured on machined castings under ordinary production methods. However, where extreme accuracy is needed in a die-casting, a sizing operation should be allowed for.

Tin and lead-base die-castings can be held to a total variation of 0.001 in. per lineal inch or fraction thereof. In the case of zinc and aluminum alloys, this total variation would be 0.002 and 0.004 in. respectively. These figures represent average conditions, and are not always in direct proportion to the total length of the die-casting.

Machining Die-Castings

Die-castings, as they leave the die, have flashes of metal attached which are known as "fins." These are more pronounced along the parting surface of the die, due to the spring when the metal is forced in and to the intentional vent grooves ground on the die surfaces. Fins also will form around cores, slides, ejector pins and other movable parts. Even around stationary blocks, fins will form eventually, due to the constant expansion and contraction and the stretching of the holding screws. However, these difficulties are at the minimum when the dies are constructed securely, lubricated properly and have the surfaces kept clean during the casting operation.

Die-castings usually are delivered with fins filed off, but this tendency should be considered to provide proper clearance in jigs and fixtures used for subsequent sizing operations on important dimensions. In using cored holes for locating points, one should consider from which half of the die they are formed so that the most accurate results are obtained. If, for example, a certain hole is to be reamed, locate from the portion of the die-casting formed in that half of the die which also carries the core for the particular hole to be sized.

Tools for die-castings should be made of high-speed steel and ground with acute cutting-angles. The clearance and rake for zinc can be about the same as that for steel, and practically twice as much for aluminum. It may be greater for the tin and lead alloys. Taps, reamers and milling cutters should be provided with large flutes for chip clearance. The cutting speeds for zinc die-castings are 15 to 25 per cent faster and for alu-

minum 30 to 50 per cent faster than the speeds for cast iron. The feed, however, should be about 20 per cent slower.

The cutting edges must be kept sharp because of the tendency to tear, particularly in the aluminum alloys of low copper-content. In the case of zinc die-castings with thin walls, cracks may develop due to the wedging action of a dull tool. Holes for tapping should be about 0.003 in. larger in diameter than standard practice to prevent crowding of the tap.

Soldering Die-Castings

The main precaution in soldering zinc die-castings is to maintain a temperature below 250 deg. fahr. to prevent sweating out of the tin constituent. The castings also must be handled carefully, since zinc alloys are weak when hot. A suitable flux is a solution of zinc chloride. Powdered resin also can be used, but it is more difficult to handle. A low-fusing-point solder should be used; it must be thoroughly rubbed into the surface with a soldering iron, so that it will alloy with the zinc. When possible, the casting should be warmed all over before applying the iron, so that excessive heating at the soldering point will not be needed to compensate for conduction of heat to the cold sections.

Polishing Die-Castings

Unlike brass castings, white-alloy die-castings cannot be polished with a dry roughing wheel due to the softer and more porous texture of the metal. The dry wheel drags around the pores and leaves marks that cannot be buffed out. Soft canvas wheels, or wheels consisting of sections of stitched buffs glued together can be used to polish white-alloy die-castings. The emery is applied in the usual manner by first coating the wheels with a good grade of glue. The grade of emery depends upon the quality of finish desired and upon the composition of the alloy. For the aluminum, No. 90 emery is used for cutting down, and can be followed by No. 120 emery. In the case of zinc die-castings, the No. 90 emery is not needed because of the greater ease in grinding down the uneven ridges left by the removal of fins. It is essential that the wheels be kept wet or greasy with fat or tallow. Care must be taken not to grind too much below the natural dense surface of the die-casting, thereby reaching the porous structure usually present toward the center of the wall. Zinc die-castings should not be permitted to become so hot in polishing that they cannot be touched with the hand. Otherwise, cracked castings will result, and if tin is present it will sweat-out and leave minute holes on the surface, this frequently being the cause of

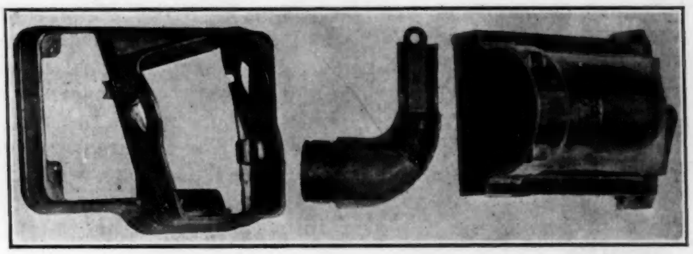

Fig. 4—Other Special Castings
The Left View Represents a Check-Protector Housing. The Elbow Shown at the Center Is Cut in Two, Illustrating the Use of a Loose Core To Eliminate the Sharp Corner That Ordinarily Would Be Produced. A Motor Housing for a Vacuum Cleaner Is Shown at the Right

blistered plating. Aluminum die-castings can be given a satin finish either by dipping in suitable chemicals or by the use of a special wire-brush wheel after the grease or oil is removed from the surface.

Enameling and Plating Die-Castings

All die-castings can be enameled readily provided the thin film of oil or grease due to handling or machining is removed by dipping them into a suitable wash. Sand blasting causes the enamel to stick much better to the smooth surface. Enamels requiring a baking temperature of no higher than 250 deg. fahr. should be used for the low-melting-point alloys; otherwise, tin, which is present in many zinc die-castings, will sweat-out and cause trouble. Zinc die-castings free from tin can be baked at a somewhat higher heat, but care must be taken not to reach the critical temperature, or the castings will become brittle. The most satisfactory results can be obtained with an air-dried enamel that eliminates the necessity of a final baking.

Zinc die-castings can be plated readily. This gives the castings an improved appearance and the necessary protection against oxidation and deterioration, this being an important factor in zinc alloys subjected to the action of the elements.

Certain simple precautions should be exercised to obtain the most satisfactory results. Grinding too far below the surface should be avoided. To clean die-castings prior to plating, they should be dipped for only a few seconds in a weak caustic-soda solution. They should come out of the bath bright, and if they show a tarnished appearance, it is an indication that they were immersed too long. Such a condition will cause pitting of the work. The solution should not reach the boiling point, but should be kept to about 158 to 176 deg. fahr. to prevent it from working into the pores of the metal.

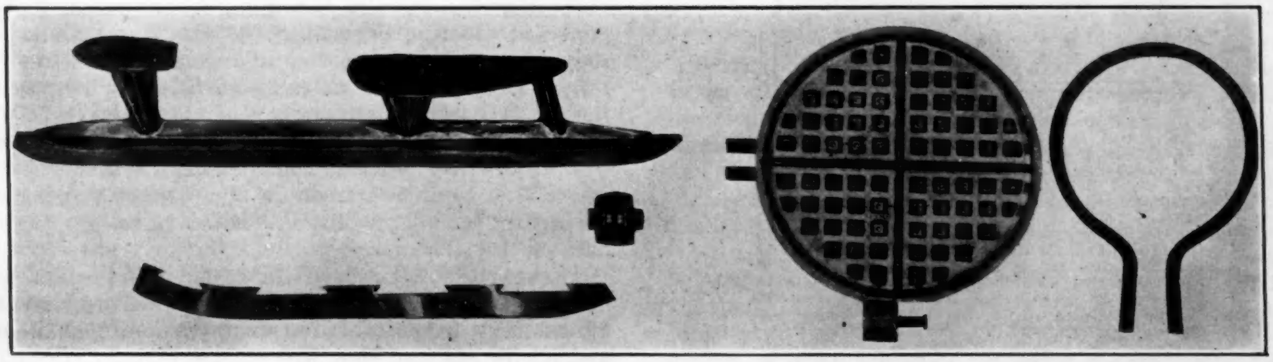

Fig. 3—Castings of a Waffle Mold and of an Ice Skate
An Aluminum Skate-Base Having a Hardened-Steel Runner Cast in Place Is Shown at the Left, the Method of Anchoring Being Shown in the Separate View of a Similar Runner. At the Right, a Waffle Mold Is Shown That Has an Inserted Steel Hinge and also the Electrical Heating Element Cast in Place, the Latter Being Shown Separately

Zinc die-castings can be given a direct plating of nickel but, for fine work, a copper or brass "strike" before final plating is desirable. Since zinc is acted upon easily by the elements of the plating bath, it is necessary that the entire surface of the part be covered instantly with a protecting coating of metal. For this reason the initial voltage should be as high as possible, without burning the deposit, usually 4 to 5 volts, and then reduced to 2 to 3 volts for the remaining period of the plating operation.

Die-Casting Methods

Die-casting equipment consists of a container for molten metal that is capable of withstanding high pressures, a die or mold into which the molten metal is forced and a suitable frame for opening and closing the die. Casting machines are divided into two general classes; namely, air machines and plunger machines, depending upon whether the metal is forced in by air or by a mechanical plunger.

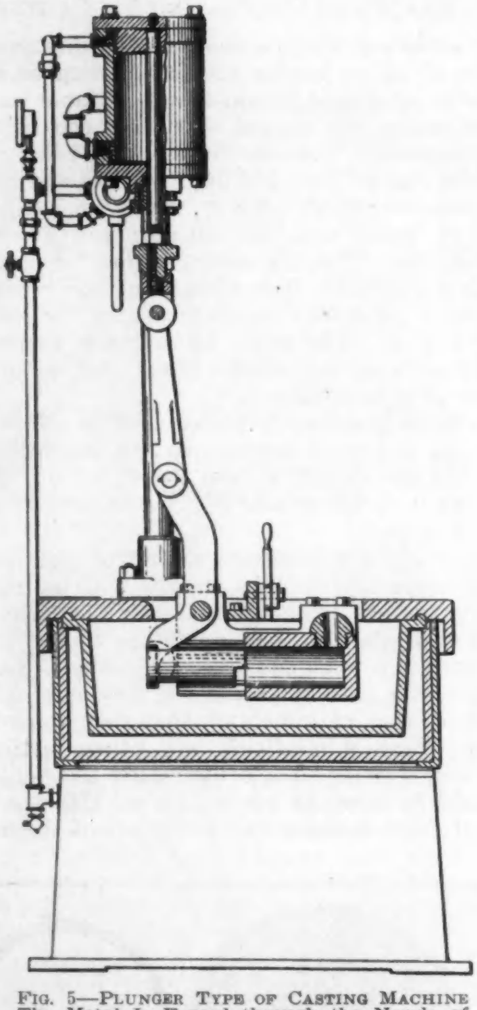

Fig. 5—Plunger Type of Casting Machine
The Metal Is Forced through the Nozzle of the Pressure Cylinder by a Plunger Actuated by an Air Cylinder through a Connecting-Rod and a Rocker-Arm. The Pressure Cylinder is Submerged in a Pot Containing Molten Metal. When the Plunger Is in the Position Indicated, the Metal Flows into the Pressure Cylinder Through the Slot at the Bottom and Is Ready To Be Delivered to the Die on the Next Stroke. The Die Is Mounted in a Suitable Frame, Not Shown, Which Swings into Position So That the Gate Registers with the Nozzle of the Pressure Cylinder

Fig. 5 shows a plunger-type of casting-machine. The metal is forced through the nozzle of the pressure cylinder by a plunger actuated by an air cylinder through

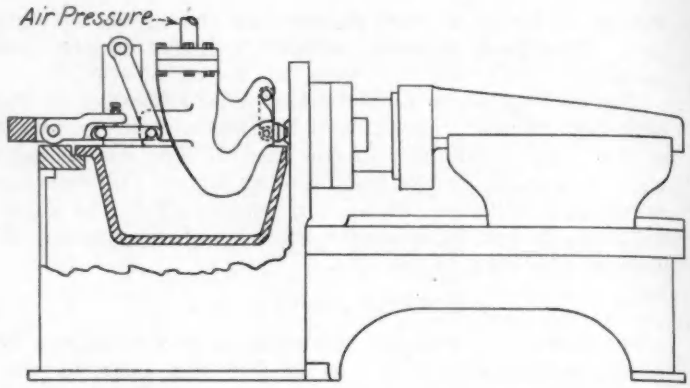

Fig. 6—Air-Pressure Type of Casting-Machine
The Pressure Pot, Known As a "Gooseneck," Is Supported on Suitable Links That Permit It To Be Submerged in the Metal Pot after Each Casting Operation. The Metal Flows into the Gooseneck, Thus Charging It for the Next Casting. When Locked against the Nozzle Seat of the Die, the Air Pressure Is Applied by Air Admitted through the Top. This Type of Pot Is Best Suited for Aluminum Alloys

a connecting-rod and a rocker-arm. The pressure cylinder is submerged in a pot containing molten metal. When the plunger is in the position indicated, the metal flows into the pressure cylinder through a slot at the bottom and is ready to be delivered to the die on the next stroke. The die is mounted on a suitable frame, not shown, which swings into position so that the gate registers with the nozzle of the pressure cylinder.

Fig. 6 shows an air-pressure type of casting-machine. The pressure pot, known as a "gooseneck," is supported on suitable links that permit it to be submerged in the metal pot after each casting operation. The metal flows into the gooseneck through the nozzle, thus charging it for the next casting. When locked against the nozzle seat of the die, the air pressure is applied by air admitted through the top. This type of pot is best suited for aluminum alloys.

To gain some idea of the production capacity of die-casting machines, the frame shown in Fig. 5, equipped with a plunger cylinder for lead alloys and with a multiple-impression die, was capable of producing 100,000 fuse holders for hand grenades in 24 hr. during the war period; in other words, it was pumping nearly 1 ton of lead alloys in each hour of operation.

Limitations of Die-Castings

The die-casting process has its limitations, the same as any other process. It cannot, for example, compete with punch presses or automatic screw machines and those parts that ordinarily are made of brass or steel should not be die-cast. Failure of parts well suited to the process is due, in the majority of cases, to incomplete information regarding the conditions under which they are used and consequent incorrect selection of the proper alloy. One is no more justified in merely ordering a die-casting without proper consideration of the specific alloy best suited, than he would be in ordering a piece of steel without considering whether it is to be a low or a high-carbon or an alloy-steel. A progressive die-casting company has, or should have, the necessary data on the alloys.

The group of tin-base die-castings finds its largest field of application in bearings for engines. Tin-base die-castings are suitable for small parts on galvanometers and player pianos; they are not affected by water, weak acid or alkaline solutions and, when free from lead, are extensively used for parts of soda fountains, cream separators and the like.

The lead-base die-castings are used for low-pressure bearings, ornamental metalware and parts that come into contact with corrosive chemicals, as in fire extinguishers. They should not be used for parts that come into contact with foods. Their main advantage lies in their comparatively low cost.

Zinc-base die-castings should not be used where they are subject to sudden shocks. They are corroded by alkaline or aqueous solutions of any salts. They tarnish when exposed to ordinary atmospheric conditions, but they can be protected with any kind of a plating, coating or enamel finish, preferably of the air-dried type. Great care must be exercised in alloying zinc-base die-castings because of the tendency toward deterioration, due to crystal growth. Zinc-base die-castings are used extensively for automobile parts, for calculating and vending machines, for pencil-sharpening machines and the like.

Aluminum die-castings do not deteriorate under atmospheric conditions. They are used on vacuum sweepers, and on automobiles in the form of steering-wheel spiders, throttle-control sets, brakeshoes, deck bars and parts of a kindred nature.

It is evident from the foregoing that the art of die-casting fills a distinct want in modern production. It is in line with the tendency of the times to permit the skill of the trained man to be used repeatedly by others who are less skilled. It is in a similar way that the skilled singers and actors produce the original records and films, the skilled operator prepares the roll for the pianola or the monotype and the skilled mechanic constructs the original cams for the automatic screw machines. Die-casting merely is another manifestation of this tendency. The skill of the tool maker, embodied in the construction of intricate dies, is used by the unskilled workman in reproducing castings that have high quality and quantity value.

THE DISCUSSION

D. M. Avey[2]:—I have noted two trends that I think promise great good for the future of permanent-mold casting. One is the willingness of firms that have been successful in this work to share their information; the other is the interest of automobile manufacturers in permanent-mold castings.

For manufacturers to tell exactly what their products will do and what can be expected from them is good. It is worthy of note that no progress is made in any line where a barrier of secrecy is set up. Contrast European foundry practice with that which obtains today in America. I need draw no detailed comparison. I think it is universally accepted that, in practice, at any rate, America excels. In Europe, when one visits a foundry he is received in a sort of entry room having a single door connecting to an inner office. Usually, this door possesses a slotted eye-hole similar to that maintained at the entrance to meeting places of secret orders. In America, the doors usually are wide open. Visitors are received and welcomed. The effect has been noticed in many lines, notably in the malleable-iron industry which, many years ago, dropped all pretense of secrecy and adopted the policy characterized by its willingness to show what it is doing and how it is done.

That a group of automotive engineers is sufficiently alive and interested in permanent-mold work to hold a meeting of this character is gratifying. The greatest progress in the foundry industry has been made since the automobile hooked-on and pulled it out of the sand. It is a fact that the automobile has made it possible to demand a cylinder with thin walls and phenomenal accuracy. Such a foundry product really dates back to when the automobile engine demanded from the foundry a cylinder-block of this character. Not content with this, conditions demanded that it should be made better and better on a production basis and at a cheaper price.

Mr. Stern has given a splendid summary of the different kinds of permanent-mold castings. I might revert to that for a moment to add one class of permanent-mold casting that was not mentioned. I have reference to that process wherein a stated amount of metal is introduced into a mold and then a core is forced into place, thus compressing the metal. This process is not forging, for the metal is fluid, yet it is not die-casting in the proper sense, because the impression is formed by forcing the core into the mold.

Mr. Stern referred to centrifugal casting in brief form. In 1913, the De Lavaud process of making centrifugal castings was introduced. The rights at first were held by a Canadian firm and by them later licensed in this country and abroad. This process was adapted to make a cast-iron pipe in centrifugal molds. The molds were rotated, were water cooled and the metal was introduced in a long trough that permitted the molten metal to reach first the remote end and then, as the mold was withdrawn, to be distributed evenly along the entire length. The molten metal was thrown to the outside by centrifugal action and the outer shell of the pipe formed against the interior of the mold. No core was used.

Experimental work has gone forward in other lines based on the same general idea. Brass sleeves for propeller-shafts have been cast by this method. Some experimental work has been done on steel with, I understand, more or less success. The cast-iron-pipe process has been handicapped somewhat because competition is so keen on a price basis in the sale of this commodity. The prices are such that it really behooves the pipe manufacturer to put the cheapest possible material into his castings. While in the sand-cast pipe we can use an iron low in silicon content, which is cheaper, it is necessary to use an iron high in silicon content in making centrifugal pipe and afterward to anneal the castings. However, a saving of about 25 per cent in the weight of metal per length of pipe is effected in the permanent-mold centrifugal-process.

Perhaps the most thorough if not the original investigator along permanent-mold lines is Edgar A. Custer, who started in 1902 to make gray-iron castings in iron and other permanent molds. While his work has been discontinued, I believe that it was due more to financial limitations than to actual inherent difficulties of process or product. He has laid a groundwork of experiment that has been the starting point in this country of many diversified lines of permanent-mold investigation. By permanent molds, I mean iron or other metal molds into which the molten metal is introduced without pressure. In his experiments, Mr. Custer found it necessary to get a casting out of the mold quickly. The iron sets first and then expands and for that reason he had to get it out quickly. Further, a chill is set up immediately after the casting sets. Mr. Custer used molds that were exceptionally heavy and this was another handicap. Perhaps the modern tendency to water or oil cooling may overcome these other tendencies.

In using a heavy mold-structure, Mr. Custer encountered mechanical difficulties in enclosure and, of course, he had a high original-mold cost. He experi-

[2] Managing editor of *Foundry*, Cleveland.

mented with different kinds of coating for the face of the mold. His paper given in 1909 before the American Foundrymen's Association outlines 15 or 20 different kinds of coating, ranging from shellac cut with alcohol to amorphous carbon. The latter has been favored by some later experimenters along these lines.

It is interesting to note how permanent-mold investigation has spread in so many different lines. I am not at liberty to say all I would like to say but I have seen a number of different permanent-mold installations that have gone beyond the experimental stages. Up to the present time we know of bevel gears that have been made successfully in iron molds, that have been produced repeatedly, have had a mold life ranging up to 250,000 castings from a single mold. Some experimental work has been done along the lines of automobile parts. You all know that plow points and carbureter parts have been made successfully. Fittings for soil pipe and soil pipe itself have been produced. Projectiles were made in permanent molds during the war. Experimental work has been done on cast-iron radiator-sections. All these things are coming about simultaneously and it stands to reason that, with the attention being given permanent-mold work, it should develop rapidly in the near future.

The points outlined in favor of any sort of permanent mold are accuracy, uniformity as to size, reduction of machining, better service, the fact that continuous production is possible and that unskilled labor can be used. Against that we have the expense of initial installation, the high cost of molds, the difficulty of maintaining accurate weight and section against the force of metal, the chilling effect that must be overcome and, of course, the inability of automobile engineers to make minor changes whenever the spirit moves them.

Will Mr. Stern tell what the variation in the life of molds used for zinc-base and for aluminum-base alloys is?

MARC STERN:—An aluminum-base alloy will run 25,000 to 50,000 operations before the life of the die expires. Sometimes it runs down even to 10,000, depending entirely on the heat-treatment of the die and the wall thickness of the die-casting. Aluminum dies are made of special alloy, but white-metal dies are made of medium-carbon steel. The aluminum dies are heat-treated but, in spite of that, the constant action of expanding and contracting causes cracks.

MR AVEY:—What is the average number of castings produced per hour?

MR. STERN:—That depends on the casting. Ordinary castings will run 100 operations per hr. Some of the more advanced machines will go up as high as 300 operations per hr.

QUESTION:—What length of time should a zinc-base casting be submerged in the plating tank to obtain a bright nickel finish?

MR. STERN:—For an average time of about 20 min., under ordinary plating methods.

A MEMBER:—Reducing the length of plating time is very important. It has been found possible to produce a nickel deposit on a die-casting in 7 to 8 min. that will withstand buffing to a very high finish.

CHAIRMAN GEORGE L. MCCAIN[3]:—The use to which the part is to be put has considerable bearing on such a matter.

C. W. JACKMAN:—What is necessary to obtain a fused bond between a casting and an insert, in contrast to mechanical keying, as with knurls, lugs and the like?

MR. STERN:—No real mechanical bond exists between the insert and the die-casting. It is merely a matter of anchoring it in there so that you can depend on the shrinkage of the metal to hold it.

L. K. SNELL:—How are minute cracks detected that may develop into failure later?

MR. STERN:—One way is to sound the casting. That method is used in inspection. It is often difficult to find the cracks; sometimes they are not visible until the castings are plated. After a casting has been produced, one can tell usually whether or not it is strained. If it shows bright shiny spots, it indicates that the casting has been strained in the die.

E. A. COUSINS:—How much below the melting point of the given alloy is the die temperature kept?

MR. STERN:—The die temperature in a zinc-base metal probably will run about 400 deg. fahr. For aluminum it runs perhaps 100 or 200 deg. higher. The metal is forced-in and chilled instantly. The water channels take the heat away very rapidly.

MR. COUSINS:—Assuming that a correct temperature exists, what is the effect of variations above and below it?

MR. STERN:—If the temperature on the die is too low, the casting will not fill out properly. Certain sections will chill and form run marks. If the temperature is too high and if the casting contains tin, the tin will sweat-out. One must provide enough water cooling to carry the heat away.

F. F. KISHLINE:—What unit pressures can be used on bearing surfaces, and which alloy is best suited for wearing qualities with highest strength?

MR. STERN:—That is a very difficult question because so many different kinds of alloy are used. The tin-copper alloys usually will withstand higher pressure than the tin-lead alloys.

CHAIRMAN MCCAIN:—The fact that die-castings are used for main bearings seems to indicate that the pressure can be rather high.

MR. STERN:—It cannot be any higher than that of the same alloy made by ordinary casting methods.

A. B. MACHON:—What is the amount of shrinkage of die-castings?

MR. STERN:—Zinc die-castings shrink from 0.004 to 0.005 in. per running inch. That does not mean that the casting itself shrinks that much. It must be borne in mind that, when it is heated-up, the die is larger than when it is cool. The difference in the die-casting is 0.004 to 0.005 in. from the time it is removed from the mold until it reaches the cold state.

MR. MACHON:—About what is the cost of a die?

MR. STERN:—A die of the elbow character shown in Fig. 4 of my paper probably would cost about $450. The cost will run up to several thousand dollars, depending on how complicated the die is. Dies for aluminum castings cost considerably more than those for white metal.

MR. MACHON:—Is the die hot? If so, how is it heated?

MR. STERN:—When it is first started, an ordinary torch is applied. After it is in operation, the heat of the metal flowing in will keep it hot enough to keep it running steadily.

CHAIRMAN MCCAIN:—In other words, it is necessary to keep it cool.

MR. STERN:—Yes, that is the important point.

MR. MACHON:—What kind of steel is used for dies?

MR. STERN:—The white-metal dies are of ordinary machine-steel of medium-high carbon-content. The steel used for aluminum dies is chrome-vanadium steel or some alloy-steel.

MR. MACHON:—How is the proper temperature of the dies maintained?

[3] M.S.A.E.—Automotive engineer, Link Belt Co., Detroit.

Mr. Stern:—The proper temperature is controlled by the flow of water through the dies. There is no way of measuring it. It is simply a matter of skill of the operator to determine whether the die is too hot or too cold.

Mr. Machon:—How is the temperature of the metal regulated?

Mr. Stern:—The temperature of the metal is watched by observing a pyrometer and the various methods that have been made for controlling the temperature automatically, but it seems that no successful method has been found. The valve is juggled when the temperature is too high or too low.

Chairman McCain:—Has any attempt been made to use automatic regulation of temperature?

Mr. Stern:—Yes, but it is very difficult to control because the zinc attacks any iron or steel put into it, and anything that sticks into the vat will be eaten up.

A. T. Bateman:—What provisions are made for heating inserts before the casting is poured, and at what temperature should they be to get the best results?

Mr. Stern:—If small, usually the inserts need no heating. If they are large, they are placed on the top of the furnace and held there until they warm up a bit. Around the boiling point of water, 212 deg. fahr., is the temperature used for that purpose.

G. H. Allen:—What makes a die-casting, such as a radiator cap, grow larger?

Mr. Stern:—It is due to several causes. Zinc-base alloys are subject to deterioration under moisture and heat, and both those conditions exist. If the elements used in the alloy are not what they should be, or if tin is mixed in with the aluminum in zinc-base alloys, it is a fact that zinc die-castings will grow rapidly due to crystal growth, but the growth would be almost negligible if the material is alloyed properly.

A. A. Bull:—Where an insert is cast in place in a die-cast-aluminum or zinc-base part, will it remain tight if the part is subjected in operation to temperatures that create expansion?

Mr. Stern:—It depends; I say "no" when used under normal temperature conditions. For example, a waffle-plate hinge, die-cast, is subjected to heat and a casting is anchored-in. The casting must be secured solidly in place and ordinary expansion over a small section of that kind will not be enough to reduce it much. The zinc may tend to corrode and loosen up in time and, in that case, a brass insert is more desirable.

Question:—At what temperature is aluminum cast under high pressure?

Mr. Stern:—About 1250 deg. fahr.; although it may run to 1300 deg. fahr.

Mr. Bull:—Regarding the insert cast in aluminum, the point in question was the possible loosening where temperature caused expansion and the parts were subjected to pressure or vibration in operation, as in a piston.

Mr. Stern:—If a part becomes heated, naturally the insert will become heated in proportion. In aluminum, having high shrinkage, the insert might loosen-up. If a die-casting is heated to 500 deg. fahr., the insert is heated to the same degree. The difference in relationship is not so great; it is simply a difference in expansion between aluminum and steel or brass. The factor is not great enough to cause any trouble within ordinary ranges of temperature.

Mr. Cousins:—How does a plastic mold differ from a metallic mold?

Mr. Stern:—A plastic mold is somewhat similar to a plaster of paris composition and has no metal in it. It was mentioned to show what is being done along the line of brass castings, as compared with die-casting.

Mr. Cousins:—Meaning that not much pressure is used?

Mr. Stern:—Yes.

Chairman McCain:—As to what is reasonable to accept and what should be rejected, a question arises regarding the percentage of parts that it is fair to return to the manufacturer of the die-castings at various times; perhaps, after the first machining, porous spots may be discovered.

Mr. Kishline:—How much surface or to what depth can the surface of a zinc-alloyed die-casting be machined without destroying the wearing qualities?

Mr. Stern:—I would say about 0.020 in. Usually, in holes for reaming or machining, allowance is made of 0.010 or 0.015 in. for machining; 0.010 in. is usually enough to leave on a side for this operation. It is not necessary to grind them much more than 0.005 in. to get down to a good finish.

Chairman McCain:—What is the approximate thickness of the skin; that is, the depth on the outside of the metal?

Mr. Stern:—It averages about 1/32 in. but that varies with the temperature of the die. The colder the die is, the deeper that skin is.

Chairman McCain:—Is the thickness of the skin a certain percentage of the total thickness of the wall?

Mr. Stern:—Yes. For a thin wall, say 3/32 in. thick, the porosity in the center core would be very slight. However, for a wall with a thickness of ¼ in., the wall does not chill so fast as a thin wall does.

Question:—For any casting, what indication on the surface of the casting will show the weakness of the casting?

Mr. Stern:—It is difficult to determine from the surface just what is inside. It may be subjected to testing by strain to find out whether it has any excess porosity. Strain would indicate it by bending. No way of determining what the inside thickness may be from the outside appearance is known.

A Member:—Is it possible to rivet or spin a flange on a die-casting?

Mr. Stern:—Yes. An example of that is the brush holder for the Ford car; it is all mounted in a steel stamping. The die-casting carries rivets cast in aluminum. They are inserted in holes and spun right over. A carbureter bowl has many holes; that it can be die-cast simply shows what can be done in a complicated piece of that nature.

Chairman McCain:—What is the effect of gasoline on a die-cast material? Does it corrode that carbureter bowl?

Mr. Stern:—A tendency for that exists. It depends, of course, on the way that is used. In some cases gasoline is used with a certain amount of oil. Oil will give protection. Pure gasoline will not affect either zinc or aluminum but, due to its impurities, it may cause trouble.

Chairman McCain:—Have you tried nickel-plating to prevent gasoline from attacking the material?

Mr. Stern:—Plating, after all, is porous. Gasoline will get through any place that water can get through. I believe that plating will not protect against it.

Chairman McCain:—I believe that a carbureter or vacuum-tank float has been nickel-plated and that it has been found to be satisfactory.

MR. STERN:—One vacuum tank has certain parts die-cast and submerged in gasoline but causes no trouble. The carbureter bowl lies in gasoline all the time. Gasoline vapor does not affect it at all. It depends on the impurities of the gasoline again.

MR. KISHLINE:—Is the surface of the material in zinc-base metal in any way hardened or improved by broaching or a similar operation?

MR. STERN:—Yes, because of the fact that broaching produces a very smooth surface. If the surface is rough, the zinc will have a tendency to grind before it adapts itself to the shape of a shaft.

THE INSPECTOR

WHILE the importance given to inspection and strict standardization in any establishment will mainly rest with the management as exemplified by the measure of executive authority granted to the inspector, much will depend upon the manner in which he impresses the real value of his work on all grades of workers and the methods by which he seeks not only to keep up the standard of quality but also to guide and assist the various departments to attain satisfactory results. Considerable moral force and courage may be necessary in carrying out his duties. The works inspection department should call attention to every error, tracing it to its source and securing its elimination from future work. The external inspector's rejections will undoubtedly call attention to serious discrepancies, but they may come too late to be of value to anyone but the buyer, and he is not likely in general to be in a position to point out that the work from a particular machine shows that it, or a jig used on it, requires adjustment.

The works chief inspector should take the initiative in submitting to the buyer's inspector, for his decision, all defects of material or machining as these are discovered. In the end he should be able to submit a completed machine, with the guarantee that every part has been through the hands of his section and that the article is wholly in accordance with the specifications and drawings, such discrepancies as he had considered immaterial and allowed being pointed out. Such cases are not frequently met, but, fortunately, they are not unknown, and with a higher value on works inspection and greater attention to it, they might be fairly common.

The employment of professional inspectors has much to recommend it, in that they have not only the proper experience and qualifications but have also, in general, a considerable knowledge of the methods and standards of leading manufacturers and can judge of their skill in any particular case. On the other hand, a member of the buyer's staff will, in 9 cases out of 10, be ill-prepared for the duties both technically and temperamentally. Although lacking the experience of inspection and its routine, he probably has, in the case of machinery for a special purpose, a better knowledge of its functions than the independent inspector who is guided by the information in the specifications, drawings and instructions given him. The maker, however, is restricted also to the same information as the inspector, who is, therefore, fully fitted to judge as between the parties on the expressed terms of the contract and not requirements that have been inadequately stated.

The basic characteristic of an inspector, in whatever capacity he is employed, is high technical knowledge combined with wide experience and sound judgment. The inspector must have a thorough knowledge of methods of measurement, and, as the quality of drawings varies very greatly, especially in the refinements of information, he may have many opportunities of exercising his judgment in defining limits, tolerances, finish, quality of workmanship and the like, which are really of the essence of inspection, although frequently they appear in specifications with a lack of precision that would provide lawyers with the subject of interminable argument. Between these extremes lies a multitude of cases, each needing to be considered on its merits and demanding from the inspector, with whom their disposal rests, a careful balance of the pros and cons when, due to shrinkage, distortion, defect or error, a departure from a drawing results.

The principle being the maintenance of one standard and the exclusion of all contentious matter from the purview of subordinates, the inspector will restrict their duties to the acceptance of entirely correct work and will himself deal with that which they find incorrect. Such men as are employed on this work, from the nature of their work and the fact that they are free from the discipline of the shops, have to be chosen carefully. For them, in only a smaller degree than for the inspector himself, the position is one of privilege, and each, while in no way bound to the manufacturer whose works they visit, must hold himself in honor bound to respect the confidence reposed in him, and, while whole-heartedly serving his employer, the buyer, yield to the manufacturer the kindly cooperation that alone can make inspection tolerable to all concerned.—*Engineering* (London).

INCOME OF AMERICAN FARMERS

FARMERS in the United States received a larger gross income from agricultural production in the year ended June 30, 1925, than in any other year since 1921, according to a statement just issued by the Department of Agriculture. The gross income is estimated at $12,136,000,000, against $11,288,000,000 the preceding year. Gross income is the value of production less feed, seed and waste. The increase of about 7½ per cent was due almost wholly to higher returns from grain and meat animals, particularly wheat and hogs.

Gross cash income from sales, exclusive of live stock and feed sold to other farmers, was $9,777,000,000, against $8,928,000,000 the preceding year. Food and fuel produced and consumed on farms was valued at $2,359,000,000. Expenses of production were $6,486,000,000, or nearly 2 per cent above the $6,363,000,000 estimated for 1923-1924. Net cash income from sales was $3,291,000,000, against $2,565,000,000. Net income from production, including with the net cash sales the value of food and fuel produced and consumed on the farms, was $5,650,000,000, against $4,925,000,000, an increase of 14.75 per cent.

Grains returned $1,934,000,000 in 1924-1925, against $1,393,000,000 the preceding year; meat animals, $2,621,000,000, against $2,167,000,000; fruits and vegetables, $1,370,000,000, against $1,526,000,000; cotton and cottonseed, $1,690,000,000, against $1,608,000,000; and dairy and poultry products, $3,284,000,000, against $3,315,000,000.

This analysis confirms other indications of improvement in agricultural income. Still, the net income per operator, including tenants as well as owners, averaged only $876 in 1924-1925, against $764 the preceding year, this covering the return on the equity in farm property as well as earnings for labor of the farmer and his family. If 4½ per cent of return for the operator's net capital investment is deducted from the net income of $876, the return for the operator's labor and management and for the labor of his family was only $649 in 1924-1925 and $531 in 1923-1924.—*Economic World.*

The Effects of Engine Operation on Lubricating Oil

By LAWRENCE T. WAGNER[1] SAN FRANCISCO GROUP PAPER

ABSTRACT

EFFECTS of engine operation on the lubricating oil used in it determines to a large extent the ability of the oil to maintain continuous lubrication and, consequently, of the engine to function efficiently. Engine operation has three major effects on the oil: (a) complete destruction of part of the oil, (b) physical and chemical changes in the oil and (c) contamination of the oil by foreign matter.

Oil is not worn out by friction but is destroyed by burning or decomposition caused by exposure to the intense heat of fuel combustion in the cylinders or the metallic parts of the combustion-chamber. The quantity so destroyed depends upon (a) fuel-combustion temperatures, (b) temperatures of the metallic parts, (c) quantity of oil exposed to these temperatures, (d) length of time of such exposure and (e) volatility of the oil.

The quantity of oil that is exposed to the destructive temperatures, and thus consumed, depends upon the mechanical condition of the engine, the operating conditions and the viscosity of the oil. With the splash system of cylinder lubrication an excess of oil is supplied, some of which passes above the piston-rings and spreads over the tops of the pistons, the combustion-chamber walls and the valve heads, where it is constantly exposed to the flame of combustion and is destroyed. Oil on the cylinder-walls is covered by the piston-skirts part of the time and is renewed at every piston-stroke, hence less oil destruction occurs there. The common practice of using an oil of high viscosity to reduce leakage past the piston-rings, thereby decreasing the oil consumption, may easily be carried too far and result in inadequate lubrication of the upper cylinder-walls and consequent excessive wear there. With an engine running at 1000 r.p.m., the duration of the power-stroke is approximately 1/2000 min., or 1/33 sec., during which brief interval only a small portion of the oil on the cylinder-walls can be destroyed.

Lubricating oil must be converted into a gas before it can burn, hence its volatility is important. The flash-test, however, is of little value and may be misleading in determining volatility, as it does not indicate the volatility of the entire mass. Straight-run oils composed of a narrow range of fractions from crude petroleum and having a straight distillation-curve may show a slightly lower flash-point than a blended oil, yet contain a smaller total quantity of the more volatile fractions than an oil having a higher flash-point and hence will have greater ability to resist heat.

Ordinary temperature changes do not permanently alter the viscosity of an oil but the specific viscosity is changed by relatively high temperature and by contamination. Distribution of oil to the bearing surfaces, ability of the oil to maintain complete separation of the surfaces, internal friction or resistance of the oil to motion and effectiveness of the oil as a piston seal are all functions of its viscosity, therefore changes in viscosity are of importance. These are caused by gradual consumption of the lighter fractions by oxidation and cracking and by the admixture of water, unburned fuel, carbon, dust and metallic particles.

The excessive quantity of fuel used when starting and warming-up a cold engine is the principal cause of dilution by fuel, water contamination is due to cold surfaces in the crankcase that condense the water vapor of combustion, dust enters the engine through the carbureter and breather-pipe and metallic particles wear off of the bearing surfaces most rapidly when wearing-in a new engine. Contamination by fuel reduces the viscosity of the oil, water forms an emulsion and, with carbon, dust and metallic particles, forms a sludge. All of these conditions are likely to have deleterious effects on the engine.

THE ability of oil to maintain continuous lubrication of an automobile engine, and, of course, the ability of the engine itself to function efficiently, is determined largely by the effects of engine operation upon the oil in use. The entire working supply of oil in the engine is kept in constant circulation while the engine is running and is used repeatedly for the lubrication of all the engine bearing-surfaces. During engine operation, the oil thus kept in circulation is exposed to high temperatures and to contamination by various foreign substances, and the wear of bearing surfaces, the piston seal and the mechanical efficiency are influenced directly by these factors. The three major effects of engine operation on the lubricating oil in use in the engine are

(1) Complete destruction of a portion of the oil
(2) Physical and chemical changes in the oil
(3) Contamination of the oil by foreign matter

OIL DESTROYED BY BURNING, NOT WEAR

Lubricating oil is not consumed or worn-out in the specific act of overcoming friction between bearing surfaces. The gradual reduction of the supply of oil in the engine reservoir, as indicated by the oil-gage, is caused principally by either the burning or the decomposition of the oil by high temperatures encountered in the engine. The quantity of oil that will thus be destroyed in any particular engine in a given time is dependent upon the following factors:

(1) Fuel-combustion temperatures
(2) Temperatures of metallic parts
(3) Quantity of oil exposed to these temperatures
(4) Length of time of such exposure
(5) Volatility of the oil

Flame temperatures in the combustion-chamber vary with compression pressures, throttle opening, characteristics of the fuel and proportion of the mixture of fuel and air, but, generally speaking, the maximum temperature in the cylinder will vary between 2000 and 3000 deg. fahr.

The highest temperature attained by any metallic part of the engine is at the center of the piston-head, which is exposed directly to the burning gases in the cylinder and is farthest removed from the cooling medium. Maxi-

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mum piston-head temperatures may, under extreme conditions, run as high as from 800 to 1000 deg. fahr., but in ordinary automobile-engine operation it is probable that the highest temperatures reached at this point will not exceed 450 deg. The edges of the piston-head at the cylinder-wall will, of course, be at a lower temperature than the center of the piston-head and will seldom exceed 350 deg. The piston skirt, or the bearing surface of the piston, will be still lower in temperature, probably not exceeding 300 deg. at any time. The temperature of the water in the cylinder-jackets cannot, of course, exceed 212 deg. fahr., and the temperature of the inner surfaces of the cylinder and the combustion-chamber is limited, therefore, by the water temperatures and by the thickness of the cylinder-wall. Ordinarily, that temperature will not exceed 250 deg. unless the circulation of the cooling water is imperfect with the formation of steam pockets in the water-jackets.

Temperatures of the parts mentioned will be higher than in any other parts of the engine, since combustion occurs in the upper part of the cylinders, and, so far as the lubricating oil is concerned, these are the critical temperatures. The various bearings in the lower part of the engine, such as crankshaft, connecting-rod and camshaft bearings, seldom, if ever, become so hot as the pistons and the cylinder-walls, and the temperatures of these bearings will seldom exceed 200 deg. fahr.

Excess Oil Exposed to Burning Gases

As the destruction of oil in the engine is due mainly to its exposure to the heat of burning gases in the cylinder, the quantity of oil that is normally in direct contact with this heat is a governing factor in the quantity of oil destroyed, or, as it is commonly termed, "oil consumption." The amount of oil thus exposed is dependent upon the mechanical condition of the engine, the operating conditions and the body, or viscosity, of the oil.

The sides of the piston skirt and the cylinder-wall constitute bearing surfaces that require lubrication, and for this purpose oil is splashed or thrown by the crankshaft and connecting-rods against the lower cylinder-walls and is carried upward by the pistons. The supply that is made available for cylinder lubrication in this way is subject to wide variation because of the lubricating systems used in present automobile engines and, to be assured of sufficient oil on the upper cylinder-walls under all operating conditions, it is necessary to allow a factor of safety that, under many operating conditions, will result in an oversupply at this place. Surplus oil spreads over the piston-head and partly covers the surfaces of the combustion-chamber and the valve-heads where, of course, it is exposed all the time to the flame of combustion and will be destroyed more rapidly than that remaining on the cylinder-walls.

At the beginning of the power stroke, when flame temperatures are at the maximum, the oil-film on the cylinder-walls is covered and protected by the piston. During the power stroke this film is uncovered and exposed to the hot gases, but the temperature of these gases is at the same time steadily dropping, and during the exhaust stroke the piston again covers these lubricated surfaces and replaces that portion of the oil-film that may have been destroyed.

Control of Oil Flow Past the Pistons

Little progress has been made by engine designers and builders in controlling the quantity of oil that is supplied to the lower cylinder-walls so that it will exactly meet the requirements of the engine at all times during operation. Their efforts have been along the line of assuring an excessive supply to the lower cylinder-wall and then cutting down or controlling the proportion of this oil that escapes upward past the pistons and reaches the upper portion of the cylinder-walls. Various types and forms of piston-ring, changes in piston design and "bleeding" of pistons are common examples of these efforts. It is possible in this way to control, to a certain extent, the quantity of oil that passes the pistons.

A common practice is for vehicle operators to reduce the oil consumption by using an oil that possesses sufficient body, or viscosity, to resist this leakage past the pistons and thus to cut-down the quantity of lubricating oil that is exposed to the destructive effect of flame temperatures. This practice, however, can easily be carried too far and result in inadequate lubrication of the upper cylinder-walls. A common evidence of the evil effects of using an oil that is too heavy for full distribution to the cylinder-walls is the condition of the cylinders in engines that have been operated with the use of such an oil for several thousand miles. An examination of the cylinders discloses more wear at the top of the cylinder-walls than at the bottom, necessitating reboring and the fitting of oversize pistons.

Exposure Time a Factor in Consumption

As pointed out, the oil in the cylinders that passes beyond the upper limit of piston travel is exposed to the heat of combustion throughout the duration of fuel combustion and will be destroyed completely or, if present in sufficient quantity, may be carried out of the engine through the exhaust-valves in a liquid condition. The total amount lost in either case will depend entirely upon the quantity that passes the upper limit of piston travel, and the relative time of its exposure is not a governing factor. The destruction of oil on the portion of the cylinder-wall that is included in the piston travel is affected, however, by the time-element, because exposure of the oil is not continuous. An appreciable length of time is required to destroy lubricating oil by burning, hence the duration of each exposure is a factor in determining the quantity of oil that will be destroyed in a given length of operation.

Engine speeds in present automobiles vary from starting speed to approximately 3000 r.p.m., and speeds of 1000 r.p.m. or higher are maintained during most of the time of operation. With an engine running at a speed of 1000 r.p.m., the time required for one piston stroke, or the duration of the power stroke, is approximately 1/2000 min., or 1/33 sec. In this brief interval it is possible to destroy only a small proportion of the total quantity of oil on the cylinder-wall and it will therefore be apparent that, if it were possible to prevent the passage of oil beyond the rubbing surface of the cylinder, oil consumption from this cause would be at the minimum. This is impossible, however, with present lubricating systems if sufficient lubrication is assured under all operating conditions, because, under some conditions, surplus oil will get into the combustion-chamber, unduly increasing the consumption.

Flash-Test of Volatility May Mislead

With temperatures and time-interval of exposure fixed, the quantity of oil destroyed or consumed in any particular engine becomes a question of the quantity of oil that is exposed and the volatility of the oil in use. With a given quantity of oil exposed to the heat of combustion, the consumption or destruction of the oil will be dependent upon its volatility.

Lubricating oil must be converted into a gas before it will burn, and this evaporation or gasification will occur whenever the oil is exposed to sufficient heat. The temperature of burning gases in the cylinder is high enough to vaporize any lubricating oil, but the quantity vaporized within a given time will be dependent upon the rapidity with which it responds to such heat. Oil gasified in this way is burned or decomposed and the quantity thus destroyed is, therefore, a function of its volatility.

This characteristic of lubricating oil is frequently spoken of as its "ability to resist heat," and the common impression exists that such ability is indicated by the fire and flash-test of the oil. The flash-point or flash-test is that temperature at which the oil will give off vapors or gases in sufficient quantity to support combustion intermittently, but the gases thus given off are the result of vaporizing the lighter or more volatile fractions of the oil and the volatility of the entire mass is not thus indicated. To determine correctly the ability of the lubricating oil to resist heat, or to fix its true volatility with reference to engine operation, it is necessary to make a fractional distillation, ascertaining the different temperatures at which varying percentages of the oil will be vaporized until the entire quantity has been converted to gaseous form.

The flash or fire-test as ordinarily used in oil specifications is not only of little value in determining the ability of the oil to resist heat but it may be directly misleading. Straight-run lubricating oils, or those composed of a comparatively narrow range of fractions from crude petroleum and having a straight distillation-curve, may show a slightly lower flash-point than a blended oil and yet contain a smaller total quantity of the more volatile fractions than an oil having the higher flash-point. Under such conditions, the oil will have greater ability to resist heat even though it may show a lower flash or fire-test.

Physical Changes and Their Causes

Changes that occur in the oil in use in an automobile engine are principally the result of exposure of the oil to high temperatures. Violent agitation and the admixture of certain impurities are contributing causes, particularly with respect to permanent changes that may occur.

All lubricating oils are alike in that they undergo changes in their viscosity with changes in temperature. When an oil is cold or at a comparatively low temperature it is thick, heavy and sluggish and its viscosity is high. When the oil is hot or at a comparatively high temperature its viscosity is lowered and it becomes thinner and more fluid. A corresponding change in viscosity occurs with any change in temperature and this natural characteristic is of importance as affecting engine lubrication. Distribution of oil to the various bearing surfaces in the engine, ability of the oil to maintain complete separation of the bearing surfaces, its internal friction or resistance to motion and its effectiveness as a piston seal are all functions of its viscosity. It will be seen, therefore, that this physical change in the oil, or the rate at which its viscosity is reduced with the application of a certain amount of heat, affects correct lubrication.

It should be borne in mind that this physical change is not in any sense a permanent change in the oil nor a change in its *specific* viscosity. For instance, an oil possessing a certain viscosity at atmospheric temperature will have this viscosity greatly reduced if it is brought to a temperature of 210 deg. fahr. and will be much thinner and more fluid at this temperature than at atmospheric temperature. However, upon being cooled and brought back to atmospheric temperature, its viscosity will be identically the same as when it was previously at this temperature. The oil will continue to respond in this way to changes in temperature but at any given temperature will always have the same body or viscosity regardless of its continued exposure to moderately high temperatures.

Causes of Permanent Viscosity Changes

A permanent thinning, or reduction in viscosity, of lubricating oil caused by the admixture of unburned fuel, or "crankcase fuel-dilution" as it is called, should not be confused with changes in viscosity caused by changes in the temperature of the oil. Fuel that becomes mixed with the oil in the engine is an impurity or a foreign substance, and the thinning of the oil in this way is not due to any change within the oil itself.

A mineral lubricating-oil is a complex chemical structure composed of different hydrocarbons or fractions from crude petroleum. As the volatility of these different fractions will vary, exposure of the oil to high temperatures may vaporize a portion of the lighter fractions, leaving the heavier ones behind, and in this way increase the specific viscosity of the remaining part of the oil. In fact, oil in use in automotive engines possesses a marked tendency to become heavier in body as its use is continued, depending upon the degree of heat to which it is exposed and the period of such exposure.

As some percentage of moisture or water will always be present in used crankcase-oil, emulsification may occur, causing the formation of soapy matter or sludge. A properly refined lubricating oil will have a high degree of resistance to emulsification in the presence of moisture but the presence of other foreign matter, such as carbon and road dust, will increase the tendency to emulsify and cause the formation of objectionable deposits.

Oxygen and Heat Cause Chemical Changes

Chemical changes that may occur in a lubricating oil in use in an automotive engine are mainly of two kinds, *oxidation* and *cracking*. All oils, animal, vegetable and mineral, tend to oxidize when exposed to the oxygen in the air. This tendency is more marked in vegetable oils and is taken advantage of in certain cases, as in the use of paint oils. One of the principal advantages of the use of a mineral oil for the lubrication of internal combustion engines is that it has the ability to resist oxidation, or the absorption of oxygen from the air. High temperatures and violent agitation of the oil, which brings it into more intimate contact with the air, will, however, cause a certain degree of oxidation of mineral oil, but this will not be detrimental to lubrication unless it is allowed to continue for an exceedingly long time. A slight darkening of the color of the oil is the most noticeable effect of such oxidation and if long continued it may cause some thickening, or an increase in the viscosity.

A lubricating oil that is manufactured from an unsuitable crude oil or that is poorly refined is likely to be "cracked" upon exposure to sufficiently high temperatures. Some of the molecules composing the heavier portions are ruptured by the heat and the atoms of hydrogen and carbon of which they are composed are rearranged to form new and lighter hydrocarbons. This action causes a reduction of the specific viscosity of the

oil and is accompanied by the deposition of more or less solid matter in the form of a residue. A good lubricating oil will not be affected in this way and repeated and long continued exposure to high temperatures will not cause any appreciable cracking or "breaking-down" of the oil.

Five Impurities That Contaminate Oil

Various impurities accumulate in the lubricating oil during engine operation which tend to prevent the oil from maintaining correct lubrication of the engine. Five of these impurities are always found in varying amounts in used engine-oil: (*a*) unburned fuel, (*b*) water, (*c*) carbon, (*d*) road dust and (*e*) metallic particles.

Under ideal conditions all of the fuel taken into the engine through the carbureter is burned. Such conditions seldom exist, however, because of more or less imperfect carburetion and as a result more or less gasoline is present in the cylinders in a liquid form during the compression and combustion strokes. Some of this raw fuel is deposited on the oil-film on the cylinder-walls and makes its way past the pistons down into the crankcase, where it mixes with the main supply of oil. The effect of this mixture of gasoline with the oil is to reduce the viscosity of the oil and, if sufficient diluent is present, the oil will be unable to maintain separation of the bearing surfaces. Under such conditions excessive bearing friction and destructive wear of the bearing surfaces will occur.

Gasoline cannot be burned until it is converted into a gas and the necessary amount of heat must be supplied for this purpose. The problem of crankcase fuel-dilution, therefore, is principally one of temperatures as affecting complete combustion of the fuel.

Starting Cold Engine Causes Most Dilution

The principal cause of crankcase fuel-dilution is the starting of cold engines and the operation of engines during the warming-up period or before sufficiently high temperatures have been created to permit of complete gasification and combustion of the fuel. To start a cold engine it is necessary to introduce into the cylinders enough gasoline to insure the presence of a sufficient quantity of the lighter portions of the fuel that can be gasified by atmospheric temperatures, assisted by the heat of compression, and which, upon burning, will develop enough power to start the engine. Only a comparatively small proportion of the fuel is susceptible to complete gasification under this condition, and the total amount of fuel taken into the cylinders will be greatly in excess of the quantity normally required for the development of maximum power. After the engine is started and until sufficient heat has been generated by engine operation to evaporate all of the fuel taken into the cylinders, more or less liquid gasoline, a large proportion of which will find its way into the crankcase and dilute the lubricating oil, will be present; and even after the operating conditions have become normal, small quantities of unburned fuel may continue to escape past the pistons into the crankcase.

If the carbureter is supplying too rich a mixture or if the cylinder-walls are not maintained at the proper temperature, the combustion of the fuel going into the cylinders will be incomplete and leakage of varying quantities of liquid gasoline past the pistons will follow. If the engine is thoroughly warmed-up and the lower crankcase is maintained at a sufficiently high temperature, more or less of the fuel that has become mixed with the lubricating oil will be vaporized and will escape through the breather-pipe. Crankcase oil-dilution by fuel will be reduced to the minimum if an engine is in reasonably good mechanical condition and continuous operation at normal temperatures is maintained. But if the lower crankcase is not warmed sufficiently to evaporate the fuel, the percentage of dilution will continue to increase until the oil is so thinned that lubrication will not be possible.

Low Temperature Causes Contamination by Water

In the process of combustion the hydrogen in the gasoline unites with oxygen in the air to form water, which is one of the principal products of combustion of the fuel. This water is in the form of steam, or water vapor, due to the heat of combustion, and is invisible. It normally passes from the engine through the exhaust-valves with the other products of combustion, none of it remaining in the engine, but if any leakage of gases past the piston occurs on the power stroke, the water vapor in these gases will enter the crankcase. The moisture will remain in vapor form if the temperature in the crankcase is high enough and will pass out eventually through the breather-pipe, but if the walls of the crankcase are cold, the vapor striking these cold surfaces will be condensed and the water will become mixed with the oil.

If the oil possesses a good emulsion-test, that is, if it has high ability to resist emulsification, a small percentage of moisture will have little effect on lubrication unless the engine is exposed to freezing temperatures over night, in which case such water may freeze in the lower crankcase. On the other hand, if the oil has a poor emulsion-test or has mixed with it a considerable percentage of solid impurities, such as carbon and road dust, the moisture present may form an emulsion with the oil, causing the formation of sludge and interfering with proper circulation of the oil.

Carbon Formed by Decomposition

Lubricating oil on the cylinder-walls is either burned or decomposed by exposure to the heat of the burning gases. If complete combustion of the oil occurs, the products of such combustion are in gaseous form and pass out of the engine through the exhaust-valves. Because of lack of oxygen and the short time available, some of the oil will be decomposed rather than burned and the residue from such decomposition is principally carbon. Incomplete combustion of fuel also results in the deposition of carbon in the cylinders and this, together with the oil carbon, is mixed with the oil-film on the cylinder-walls, whence it gradually finds its way into the main supply of oil in the crankcase. At maximum operating-temperatures the piston-head may become hot enough to decompose the lubricating oil that is splashed against its under side. Carbon formed in this way will gradually become dislodged from the piston and be mixed with the lubricating oil.

Carbon formed in the engine by decomposition of the lubricating oil, if of a finely divided nature, as lampblack, soot or powdered graphite, will not interfere seriously with lubrication of the engine unless it is present in excessive amounts. On the other hand, if the carbon is granular or gritty it will be carried to the bearing surfaces and act more or less as an abrasive. Carbonaceous matter present in the oil quickly darkens it and at the same time increases its viscosity. Excessive amounts tend to clog the oil pipes and passages and thus interfere with full distribution of the lubricating oil.

EFFECTS OF DUST AND METALLIC PARTICLES

Dust, which is always present in the atmosphere, enters the engine in two ways: (a) through the carbureter and (b) through the breather-pipe. Owing to the large volume of air drawn into the cylinders through the carbureter, a considerable quantity of dust will be deposited on the oil-film on the cylinder-walls and gradually become mixed with the main body of the oil and be maintained in circulation. A slight surging action of the air in the crankcase produces intermittent suction through the breather-pipe and causes air to be drawn into the crankcase, where any dust present in the air mixes with the oil. Friction and bearing wear, varying with the character and the quantity of the dust, will be increased by the presence of this solid matter in the oil.

It is impossible entirely to eliminate bearing wear in an engine, and metal thus removed from the bearing surfaces will become mixed with the oil. The metallic particles accumulate at a comparatively rapid rate when an engine is new and is undergoing the "breaking-in" process. This breaking-in period is simply a process of lapping, that is, the smoothing of the bearing surfaces or removal of the high spots. Very little wear occurs after the surfaces become polished and so long as correct lubrication is maintained, and the quantity of metallic particles entering the crankcase oil under such conditions is very small. The larger metallic particles may settle in the oil and not be carried to the bearing surfaces but the danger that the smaller particles will work into the bearings and result in undue wear always is present.

UNIFORM SYSTEM OF ROAD SIGNS

THE Joint Board on Interstate Highways that met recently at the Bureau of Public Roads in the City of Washington adopted a system of interstate roads and a series of standard danger, caution, direction and informational signs that it will recommend for use in marking and signing the systems selected. The standard route-marker will be a typical United States shield, painted white, on which will appear, in black, the name of the appropriate State, the initials U. S. and the route number. If possible, the route numbers will be limited to two digits for easy reading; and steps will be taken to prevent the use of the standard marker for any purpose other than marking of the selected system of interstate roads.

Among the other standard signs adopted by the Board was a white shield in a smaller size than the route marker on which will be printed the letters *R* or *L* as a precautionary warning on the approach of curves or turns in the routes. A similar sign with the addition of an arrow pointing in the proper direction will be posted immediately at the turn. A circular sign 24 in. in diameter with a yellow background and bearing the familiar railroad cross in black with the letters *R R* also in black in the upper quadrants has been adopted for use at railroad grade-crossings. The standard stop-sign adopted is a regular octagon with the word "Stop" in black letters on a yellow background. The caution signs are diamond shaped with a yellow background on which are superposed the warning words and symbols giving notice of curves, hills, loose gravel and the like ahead. In addition, provision has been made for the use of "look" or "attention" signs to be used near schools and other points. These signs will be square with a yellow background and black letters.

In selecting the colors and shapes the Board has been guided by the principle that all signs indicating the necessity for any degree of caution shall be yellow. The degree of caution required will be indicated by the shape of the signs as well as by the words and symbols on them. Thus, a round sign will always indicate a railroad crossing; an octagonal sign will indicate positive danger and call for a complete stop; a diamond-shaped sign will be equivalent to a command to proceed with caution and a square yellow sign will call attention to the need for a lesser degree of caution.

In addition to the warning and cautionary signs, standards were adopted for various forms of informational and directional signs, all of which are to be rectangular in form and to have a white background with black letters. With respect to luminous signs, the colors approved are red for danger or stop, yellow for caution and green to indicate "Go."

TRUCK TANKS TO BE REGULATED

AFTER a study of more than 2 years the National Conference on Weights and Measures has adopted a code of specifications and tolerances for tank wagons and trucks when these are used as measures in the selling of petroleum products. A code on this subject was first proposed at the Sixteenth Annual Conference held in 1923 and was tentatively adopted at that time. This tentative code formed the basis for study of the subject in the last 2 years on the part of weights and measures officials, manufacturers of vehicle tanks and oil companies that use these tanks in the distribution of their products. The specifications and tolerances that have now been adopted are the result of an effort to harmonize all of the conflicting viewpoints of the different interests involved.

The principal requirements of the code, which has been developed with the assistance and cooperation of the Bureau of Standards, are that (a) each compartment of a vehicle tank shall be provided with an indicator within the fill opening, (b) it must be possible to drain completely any compartment of a tank when the vehicle is standing upon a level surface, (c) compartments and their respective faucets shall be plainly marked with designating letters or figures and (d) adjacent to the faucets the capacities of each compartment shall be shown to the nearest ½ gal. A table of tolerances or permissible variations is included in which are shown two sets of values, one to be applied on the first test by a weights and measures official and the second to be used on subsequent tests. Except for the minimum value, the tolerances on first test are one-half of those permitted on subsequent tests, and range from ½ gal. on a 175-gal. compartment to 3 gal. on a 1500-gal. compartment.

Some of the requirements of the code are designed to apply to all tanks in use, while others are to be applied only to new equipment. Adoption of this code by the National Conference does not put it into legal force and effect, but the Conference recommendation that it be officially promulgated by State and city weights and measures departments throughout the United States will undoubtedly result in its adoption by many such departments in all sections of the Country.

Characteristics of the Internal-Combustion-Engine Governor

By EDWARD F. LOWE[1]

NEW ENGLAND SECTION PAPER *Illustrated with* CHART

ABSTRACT

EXCESSIVE motor-vehicle speed caused 40 per cent of the major fatalities in the first 7 months of 1924, according to a recent bulletin issued by the National Automobile Chamber of Commerce. The author cites statistics to show that, although commercial vehicles constitute only 24 per cent of the motor vehicles in New York City, 53 per cent of the 1924 accidents there were from this source. Basing his claim for the necessity of governing motor-vehicle speed on these and similar citations, and on affirmative replies to a questionnaire sent to owners of large motor-truck fleets, to the effect that vehicle-speed governors are desirable, the author describes the different types of governor available and discusses the capabilities of each.

Following this he states 12 characteristics of a good governor. In conclusion, a gasoline-engine governor is characterized as a watchman who safeguards the owner's investment, reduces maintenance costs and increases the useful life of the vehicle.

REDUCING the number of automobile accidents has become a problem of national importance, largely due to the increasing number of motor fatalities which are reflected in high insurance rates, the destruction of highways and increasing maintenance costs to the commercial-car owner. To quote Secretary Hoover, from a recent report:

> The most challenging of all wastes is the waste of human life. There is no more conspicuous example of that wastage in our modern American life than in the mounting curse of traffic accidents. The gravity of the situation is well illustrated by the fact that the Committee of Statistics has brought in a report indicating that the deaths in 1923 were not less than 22,600 and the number of injured not less than 678,000. A total economic loss occurred of not less than $600,000,000. Also there has been an increase of 14 per cent in motor-vehicle accidents during the past year, and it is already known that this year's casualties will exceed those of 1923.

In addressing the Hoover conference, President Coolidge deplored the rise in the death rate from motor-vehicle accidents, but believed the solution is to be obtained through State and municipal action with Federal cooperation. Automobile insurance rates are to be fixed for 1925 on a basis of 30,000 deaths in approximately 1,000,000 motor-vehicle accidents. These rates can be reduced by a decline in the number of motor-vehicle accidents.

The destruction of public highways by commercial vehicles, due to over-speeding, is conservatively estimated at $150,000,000 per annum, not to mention the cost of excessive repairs to trucks resulting from this cause. Many of our roads are going to pieces under present traffic, largely because of over-speeding. At high speed, the impact caused by even a small bump becomes terrific. A 1-ton blow at 10 m.p.h. becomes a 9-ton blow at 30 m.p.h. At the 30-m.p.h. speed, the blow is more nearly lengthwise of the spring and the time for spring action is cut short, resulting in a nearly unsprung blow to the road.

It should not be assumed that automobile accidents will be eliminated entirely by restricting speed, but excessive speed is one of the many causes of accidents and, in a recent bulletin issued by the National Automobile Chamber of Commerce, it was shown that 40 per cent of the major fatalities for the first 7 months of 1924 were from speeding. It is reported also that, while commercial vehicles constitute only 24 per cent of the motor vehicles in New York City, 53 per cent of the accidents there in 1924 were from this source.

A questionnaire was recently sent to owners of a number of the largest truck fleets in the United States on the subject of governing vehicle speed. The consensus of opinion expressed in the replies was that they favor speed control and practice it because of the economic results obtainable.

It is to be regretted that more fleet owners do not keep an accurate record of the cause of accidents and the relative cost of trucks operated within the speed recommended by the truck builder and those operated in excess of this speed. Some operators of large fleets know the cost both ways and, naturally, those who are operating within the law, from both an economic and a legal standpoint, are most successful. It is gratifying to note that the owners of large fleets are the first, in most cases, to try to live up to municipal and State laws in the locality in which they operate.

UNIFORMITY OF SPEED LAWS NEEDED

Insofar as possible, it is desirable that speed laws in each State harmonize with those of the neighboring States; but, inasmuch as it is left with each State and municipality to work out an equitable law, if possible, some means should be provided for their enforcement. It already has been demonstrated that arrests and fines do not stop speeding; although administered at tremendous cost to the State. The hazards of automobile driving are bound to be more serious as the number of cars increases, and every possible precaution must be taken by drivers if the maiming and killing by automobiles is to be eliminated. The speeder who disregards his own safety and that of others ought not to have a single friend.

Most of the representative truck builders today are equipping their product with governors for their own protection and make the statement that if the governed speed is changed it violates their guarantee and they are not responsible for any resulting damage. If a truck is over-speeding, it is not only a menace on the highway but will soon rack itself to pieces. Notwithstanding this, many of the trucks are operated with governors discon-

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nected, and speed seems mainly to be desired. The driver is usually blamed for accident and damage, but the responsibility is really the owner's.

It is well known that over-speeding has a destructive effect upon the entire truck, causing rapid deterioration of tires, chassis and engine. The endurance of any mechanism is limited and, when over-stressed through the action of over-loading or shock or a combination of both, failure is bound to occur. Truck operators have shouldered repair charges for the breakage of many parts without realizing the causes underlying these effects, and how easily these causes can be eliminated.

Continuous truck operation is essential to profits and can be secured by eliminating the cause of delay. Speed, paradoxical as it may appear, is one of the chief causes of delay. Governors are used to secure uniform and economic operation. Several types are on the market which may be listed under the general classification of centrifugal, velocity and vacuum governors.

Centrifugal Governor

The centrifugal or fly-ball type governor, as used on the steam engine, was adopted for this service first, as the only practicable means of control available. Many difficulties were encountered in this means of control, for, with the steam engine running at comparatively low speeds, a governor of almost any proportions could be used and driven successfully by a belt. This offered an entirely different problem from that of controlling an internal-combustion engine running at high speed, where available space would not permit the use of the size of governor used on a steam engine. It was found impracticable to use a belt for the driving medium; so, gears and solid and flexible shafts were used.

The centrifugal type of governor gives close regulation and assurance of full power of the engine up to the governed speed. It requires lubrication. Some mechanical skill is needed to install it, especially on engines where provision has not been made for the installation of a centrifugal-type governor. Such a governor is installed between the carbureter and the intake-manifold and usually is connected with the camshaft, the valve in the gas passage being actuated by this force.

Velocity Governor

The velocity type of governor is installed between the carbureter and the intake-manifold and, as the speed of the engine increases, the speed of the gas going through the manifold is increased. By using a plunger plate or valve in the path of the gas, work can be done by it due to the force of the impact or gas-velocity applied to it. By using also a valve of a certain area and adding the tension of a spring, the valve can be calibrated to any predetermined engine speed.

To take care of the change of velocity as the valve position changes, different methods are employed. One is to use a cam that will vary the spring tension; another is to use a tapered venturi in the path of a valve to vary the velocity on it. This governor is compact and easily installed, having no driving mechanism and requiring little, if any, lubrication.

Vacuum-Type Governor

The vacuum type of governor is also actuated by the varying engine-speeds that occur by varying the load and the carbureter-throttle opening. Every gas engine has a definite manifold-depression or vacuum at different engine-speeds, occasioned by varying the speed by loading or by throttling, the highest vacuum being when the throttle is in a closing position. Measured by a mercury column, 1 in. of vacuum represents a pressure of 0.49 lb. per sq. in. As the engine speed increases, the vacuum increases slightly; but, as the load is applied and the speed is lowered, the vacuum decreases. By utilizing a piston of a certain area, and adding the tension of a spring, work will be done at a certain vacuum pressure. By varying the spring tension or the vacuum pressure, work will be done with the piston at a pressure that will correspond to any determined engine speed. This is called "calibrating" or "balancing."

As employed in one type of vacuum governor, part of the piston is used as a throttle-valve. By calibrating the movement of the piston with the manifold-depression or vacuum, the throttle-valve will maintain a definite engine-speed until the pressure is changed. As the load is applied, the pressure is decreased. This, in turn, releases the pressure on the piston and the throttle-valve is opened by the tension of the spring. The action is very quick, due to close calibration and, when the throttle-valve is opened, a clear passage is provided for the gas.

The vacuum type of governor is installed between the carbureter and the intake-manifold and is adaptable to all engines. Full power of the engine is given up to the point of cut-off. It provides close regulation, meets the constant demands of the engine and governs accurately at full or at part throttle-opening. It is common practice to seal all governor openings, so that the governor mechanism cannot be tampered with.

Characteristics of a Good Governor

The characteristics of a good governor are:

(1) Compactness and sturdiness of construction
(2) Dependability
(3) Ease of installation and adjustment
(4) Capability of being sealed to prevent tampering
(5) Ability to prevent over-speeding without affecting engine power

It should also

(6) Open within 100 r.p.m. of the governed speed, and thus provide quick acceleration
(7) Not increase the engine-speed at part throttle-opening
(8) Not over-run but cut-off sharply at the governed speed
(9) Not cause the engine to surge
(10) Be uninjured by backfire
(11) Be reasonably priced
(12) Be available for all types of gas engine

Gasoline-engine manufacturers build their engines to specifications for producing speed and power. A truck engine is built primarily for power and not for speed. Every engine has a certain speed limit, at which the greatest power is developed; beyond this point, waste and destruction occur. Therefore, truck builders usually recommend a governed speed that will be near the peak of the engine's torque-curve.

The truck owner desires all the power he can secure, together with quick acceleration, fuel economy and lower maintenance costs. It is up to the governor manufacturer to make a governor that can be installed and adjusted easily, is dependable and reasonably priced. It is of great importance that a governor should not interfere in any way with the efficiency of the engine's pulling power and carburetion. A governor should permit the truck operator to do everything with his truck that he can do without a governor except to over-speed. Governors are on the market that will do this, and governors that will not. Why should not the governor manufac-

turer be subject to standard requirements for a governor? Otherwise, no distinction is made between a governor that is efficient and one that is inefficient. Where governors are considered, it is suggested that the United States Post Office specifications be used. They are:

> A governor must control engine speed and must not reduce its efficiency rating. The construction must be such that adjustments cannot be tampered with, without the aid of tools. Efficiency, price, simplicity of construction, durability and the inability of chauffeurs to destroy the same by manipulation of the engine and the clutch are essential.

The governor is not a luxury; it is an essential. It is a watchman who safeguards the owner's investment, reduces his maintenance costs and increases the useful life of his truck.

THE DISCUSSION

L. C. MARSHALL[2]:—Our company is in sympathy with Mr. Lowe's general appeal. We know from our experience that governor equipment on the engines of motortruck fleets has proved advantageous from the standpoints of maintenance and depreciation, and no evidence has developed that the use of governors on trucks has in any way restricted their operating speed and efficiency. The increase in the number of accidents on highways attributed to commercial vehicles is molding public sentiment very rapidly toward the use of some device that will regulate and control the speed of these trucks. Inasmuch as the operators of commercial vehicles are not usually the owners, they do not feel the responsibility and, as a result, are likely to be negligent and careless. This, in itself, calls for a device that will keep the vehicles under control and serve as protection against liability of the owner.

Judging from the Hoover conference in the City of Washington, it is perfectly evident that stringent measures are to be applied against transportation units that do not operate strictly in accordance with the safety rules. If for no other reason, the owner of a fleet of trucks should equip his vehicles with an approved device that will make it possible for them to be operated in accordance with the safety codes. Any reaction against the use of governors comes only from the feeling that this equipment necessarily reduces the operating efficiency of the vehicle. When designed on scientific lines, a governor is easily applied to existing vehicles and will not affect the power output of the engine. The fact that one company in Indiana has 3000 such governors in daily use on all its trucks is evidence of their practicability. I think the specifications Mr. Lowe brought out are adequate, and we stand ready to cooperate with the manufacturers and with the Society in anything that can properly be done.

A MEMBER:—I favor governors but, while we appreciate the saving to vehicles when operated with governors and know that a number of operators of fleets have installed them, we realize that those who do not equip with them will operate at an advantage in some respects. Governors will not save the roads but, from the viewpoint of time-saving, in getting from one point to another with a load within a limited time, it can be done without a governor on occasions where it cannot be done with a governor. Considerable resistance due to that feature will be encountered.

V. A. NIELSEN[3]:—A series of tests were made by a certain motor club through a congested district. The tests showed that it is doubtful if excessive speed saved time. At best, if any time was saved, it was fractional and the excessive speed endangered the lives and the vehicles of all concerned. A driver went over a certain route, exceeding the speed limit by 5 m.p.h.; then, the same driver went over the same route again, observing all the rules and regulations for safe driving. It was found that hurrying had saved him only 5 min. per hr. over a distance of 31.5 miles. I could not sell a governor 4 years ago. I did not dare to for fear the drivers would quit, but the conditions are very different today. Will Mr. Lowe show us how the engine speed affects the governing of the engine?

E. F. LOWE:—Fig. 1 illustrates a torque curve of an engine showing where a governor should become operative. A real governor should be arranged so that it will remain wide open up to or even somewhat beyond the speed at which the peak of the torque curve occurs; thereafter, it should permit the engine to furnish any power within its capacity required by the load with a speed variation of not more than 100 r.p.m. Such a governor, because of its quick response to load requirements, will save gear shifting. Tests have been made by fleet owners on long hills. One hill 6200 ft. long was staked off and the critical points were checked-up with governors. It was found that if a governor cut-in correctly, no more gear shifting should be required with a governor than without one.

Beyond a certain speed, a drop in engine speed causes a drop in torque. If an engine with a good governor cannot pull a hill when operating at its maximum torque, it will not do so without a governor. We have gone up hills which it was said we could not pull with a governor on, and we found that one would not do it without a governor.

The main thing regarding a governor is to keep near or beyond the peak of the torque curve. Some say that a governor that cuts-in within 100 to 150 revolutions is all right; others, that governors interfere with power and, in former days, that was very true. Many manufacturers today build their governors on the same principle as that of the old fly-ball centrifugal-governor; it has more mechanism, more moving parts, a condition that is bound to cause wear. We want the smallest possible number of moving parts and to have the governor as compact as possible.

A MEMBER:—If it is required by the State that trucks be held to a speed of 15 m.p.h., we must cut the engine off below the maximum torque when in first, second and third speeds. Then, when the truck gets into a hole, it is no good.

MR. LOWE:—I grant that. Most governors on the market today govern engine speed. Below the peak of the torque curve, the engine does not operate at its greatest efficiency. The only thing a governor manufacturer can do is to install the governor to work as close to the torque curve as possible. However, this might bring speed up over legal limits. Governors should be installed so as to give the truck owner the greatest efficiency from his vehicle.

A MEMBER:—To overcome the difficulty, I would drive the governor mechanically from the transmission; that is, from the drive-shaft. Then, holding to 15 m.p.h. on high speed, you would get the maximum speed on first, second and third. I think that a governor should be driven from the chassis.

MR. LOWE:—Some centrifugal types of governor are driven from the drive-shaft.

[2] A.S.A.E.—Handy Governor Corporation, Detroit.
[3] M.S.A.E.—General manager and treasurer, V. A. Nielsen Co., Boston.

H. S. WILKINS[4]:—It is as serious to race an engine as to race a vehicle at high speed. If governed speed is desired, it would be a simple matter to connect the governor with the gearshift, and this makes it inoperative except in high gear. Not many trucks will exceed speed in low gear.

MR. NIELSEN:—Do you recommend a governor that is released except in high speed?

MR. WILKINS:—Yes, one having some device to hold the plunger back except when in high gear and then to become operative.

MR. NIELSEN:—Some day there will be car control, but it is rather expensive. Do not confuse engine-speed control with car-speed control. With car-speed control to 20 m.p.h. required, it would be necessary to change gear-ratios. Anyone can change car-speed by changing the gear-ratio of the drive.

A MEMBER:—I am not satisfied with changing the gear-ratio of a car. If we must run at 15 m.p.h., why should the engine speed be 1400 r.p.m.? That costs money. I want the engine to run at 700 r.p.m. at a car-speed of 15 m.p.h. Then, in second speed, I want a 1400-r.p.m. engine-speed. I urge a two-speed governor; in one speed, have the engine run at 1400 r.p.m.; on direct drive, hold it down to 700 r.p.m.

M. R. WOLFARD[5]:—Regarding long hauls for motor trucks, at 25 m.p.h. there is increased danger, of course. Much time cannot be saved in a city by speeding-up, but this result can be attained on a long haul. As to reducing the power of the engine, if we are forced to regulate all trucks to a limited speed, with the equipment we have today, the power of the engine is reduced because the speed of the engine is reduced. This can be overcome only by building the engine and the governor to go together. Trucks designed to run at 30 m.p.h. on direct drive, as they are today, cannot be reduced to a speed of 15 m.p.h. on direct drive without reducing their power nearly 50 per cent under some conditions. Two points are involved; safety on the road, and the problem of uphill work. Therefore, a re-design of the engine or the transmission is necessary, so as to cut the power curve at the peak. Hardship will result if trucks, as they are made today, are limited in speed.

VAN. C. WORDEN[6]:—I think we lose sight of the fact that the point of maximum torque does not occur at the point of maximum horsepower at a given engine-speed. If you reduce engine-speed, you can work back to the point of maximum torque.

A MEMBER:—What we are interested in is the ability of a truck to "get through." I maintain that if a truck meets heavy pulling with its engine running at 1400 r.p.m., it will go through it when it would not go through at 700 r.p.m. That principle will apply to all trucks.

MR. WOLFARD:—To shift from high speed into low, is the real test of the amount of power. The peak of the power curve is what counts. When you shift into any gear ratio except direct or high speed, it is maximum power, and not torque, that counts. If we want to go into second speed and obtain maximum power at the driving wheels, we must use the full power of the engine. Maximum power in this case is at 1400 r.p.m. If we have a truck going 30 m.p.h. on direct drive and

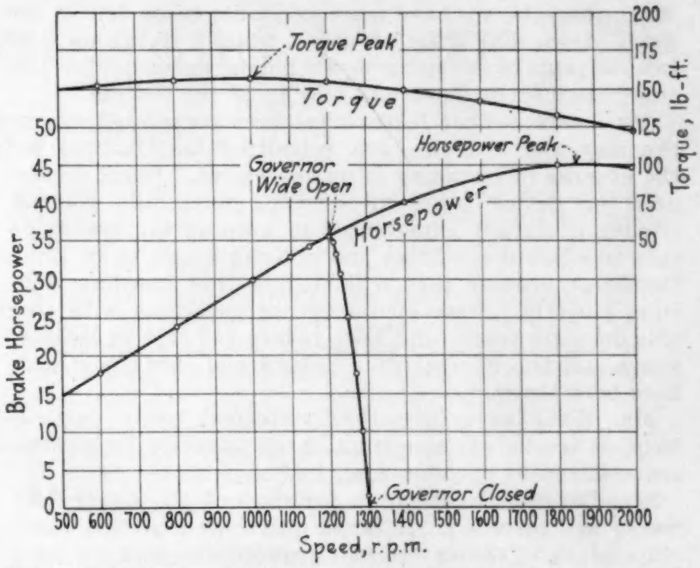

FIG. 1—CHARACTERISTICS OF AN INTERNAL-COMBUSTION ENGINE WITH A PROPERLY APPLIED GOVERNOR

A Really Efficient Governor Should Be Designed So That It Will Remain Wide Open Up to or Even Somewhat beyond the Speed at Which the Peak of the Torque Curve Occurs. Thereafter, It Should Permit the Engine To Furnish Any Power within Its Capacity Required by the Load with a Speed Variation of Not More Than 100 R.P.M. Such a Governor, Because of Its Quick Response to Load Requirements, Will Save Gear Shifting

reduce speed to 20 m.p.h., still on direct drive, we have reduced the power of the engine considerably.

MR. WORDEN:—Another point is whether we are dealing with light or heavy trucks. I was speaking of vehicles of about 3-ton capacity.

MR. WOLFARD:—Speed regulations hit ½, 1 and 2-ton trucks hard. They make long hauls. Heavy hauls are made by larger trucks, and that is not such a serious proposition. Five light trucks to one heavy truck are in operation on the roads today.

MR. LOWE:—I understand the theory regarding light trucks and think it correct. Mr. Wolfard's suggestions also are good. Nothing is on the market today that is in accordance with those suggestions, but I think they can be carried out. Any law hindering a light-truck driver is wrong. Provisions should be made to investigate and control such regulations. The statement has been made here that a truck can get through a hole by momentum, and it is true in most cases; but a governor will allow the use of the full pulling-power of the engine.

QUESTION:—In what States have regulations governing the speed of trucks been in effect in 1924?

MR. LOWE:—Illinois requires trucks to be regulated but does not require regulation for passenger cars. In Louisiana, some trucks are limited to 15 m.p.h. The law of New York State allows 5 m.p.h. additional when pneumatic tires are used; that is a fair provision, I think. Wear on roads and on trucks is undoubtedly less when pneumatic tires are used than when solid tires.

G. S. WHITMAN[7]:—Louisiana has the lowest car registration of any State in the Union, and comparatively little money is spent there on roads. The point of maximum truck-speed should be close to the curve of maximum torque. Would it be possible, without hardship to the owner or to the designer, to make a governor that cuts-off the gasoline supply at the maximum torque curve and have it cut-off at the maximum point on the horsepower curve? The truck would then have power to get out of a hole; and yet have good engine efficiency. Nothing can prevent a truck from increasing speed and exceeding the speed limit when going down hills. In

[4] M.S.A.E.—Managing engineer, lighting-plant division, H. C. Dodge, Inc., Boston.

[5] M.S.A.E.—Engineer in charge of research laboratory, Hopewell Bros., Watertown, Mass.

[6] M.S.A.E.—Manager, Stromberg Motor Devices Co., Boston.

[7] M.S.A.E.—General manager, Charles Street Garage Co., Boston.

Massachusetts, we have more accidents when trucks are going down hill than at other times. Truck drivers take advantage of going down hill to make up for lost time; they shoot down and pile up at the bottom.

MR. LOWE:—That feature has been considered by our company and a device was submitted that met it, but the expense of installing it was excessive. Truck owners need this device to prevent speeding down hill. Enough trouble is already experienced in keeping the brakes on cars in efficient condition and nothing seems to be practicable at present that will obviate this speeding difficulty entirely. Some operators use governors with success on their trucks and they reduce the cost of maintenance and the number of accidents and insurance rates have been lower.

MR. WOLFARD:—Does that statement apply particularly to trucks of more than 2-ton capacity or does it apply to trucks of 1-ton capacity?

MR. LOWE:—Probably 75 per cent of the heavy-duty trucks are governed. In large cities, we find that operators of light trucks are using governors, and we have had many inquiries.

MR. WOLFARD:—A governor for a light job is all right if it is set for a speed of 25 or 30 m.p.h.

MR. LOWE:—Allowing 5 m.p.h. additional when pneumatic tires are used, speed is a good idea.

MR. NIELSEN:—The State law provides that a truck weighing more than 2 tons may not be operated above 15 m.p.h; and if it weighs less than 2 tons, it may not exceed 20 m.p.h. Is it possible to buy a truck that will develop full power at its full gear-ratio, so it can operate efficiently at the speed prescribed?

MR. LOWE:—It can be done.

MR. NIELSEN:—The whole matter hinges on how a car is geared to the road, does it not? Nothing prevents anyone from changing a gear-ratio to bring it within the speed limit provided and obtain full power.

MR. WOLFARD:—Does the State intend to require a change in gear-ratio?

MR. NIELSEN:—The cost of the change to the truck owners would be too great.

QUESTION:—On so-called vacuum-controlled governors, the vacuum will be changed in operating the gear shift to low transmission-ratio. What difference does that make?

MR. LOWE:—You control the engine-speed as you shift. The vacuum drops at once and should pick up within 100 revolutions. The advantage of this type of governor is that it picks-up quickly and smoothly, with no lapse of time, and adjusts itself to the changing of gear-ratio quickly. Our experience with it on trucks has been that we shift as quickly with a governor as without one.

QUESTION:—Does that governor act in relation to speed? Is the vacuum controlled by speed or by load?

MR. LOWE:—Both affect it, somewhat. The vacuum builds up as the speed increases, but the increase is not perceptible. With a wide-open throttle, the vacuum is low and with a closing throttle the vacuum is high.

A MEMBER:—Having a governor on a truck that coasts down hill does help the driver in complying with the law and assists in keeping the truck out of the repair shop. I admit, of course, that accidents happen sometimes, even with governors installed. When a truck coasts down hill, an engine governor does not control, but with a maximum-speed hand on a truck's speedometer, an owner can tell if a driver has been speeding down hill, for the maximum-speed hand locks and shows the highest speed attained. This speed-hand device has really a double use; it tells the truck owner whether the driver has coasted down hill at excessive speed and also gives the miles the truck traveled during that trip or period. That is one check, even if we cannot govern the speed.

MR. LOWE:—The operator of a large fleet has kept a cost record of his trucks, which are principally 2-ton vehicles, operating with and without governors. He found that, with the governors, the cost was greatly reduced. Some claim that the maintenance cost of trucks when operated with governors is two-thirds less than when operated without them. In relation to the accident question, some records show that most accidents are traceable to light trucks that are not equipped with governors. In Massachusetts, 30 per cent of the accidents are due to conditions of too fast travel, and the same is true in Connecticut. Governor control does reduce property loss and the maintenance cost is also lowered by the use of governors. The operators of the largest fleets recommend the use of governors.

F. E. H. JOHNSON[8]:—Transmissions have been perfected now so that they take care of the matter of getting a heavy-duty truck through mud holes and such; they have a very low gear-ratio, so that they can do this without racing the engine. The passenger-car type of governor is an entirely different problem; nothing is on the market at present that would be protective. Some governors reduce excessive speeding, but no governor has yet been perfected that can stop the man who overspeeds when coasting down hill. From the governing point of view, the maximum-speed hand speedometer is the only device that can be used as a check-up. This type of instrument can be installed on either passenger car or truck and will give the information to owners of vehicles or to the police officials, showing whether or not the speed limit has been exceeded.

MR. WOLFARD:—As to speed control, Massachusetts legislates that no person shall operate a motor vehicle at more than 20 m.p.h. If light trucks are positively limited to that maximum speed and passenger cars are permitted to exceed it, as they do, is that not discrimination?

MR. NIELSEN:—It seems as though the speed limit on light trucks should be raised.

[8] M.S.A.E.—Service manager, Noyes Buick Co., Boston.

Fuel-Charge Mixing and Flame Propagation

By A. H. Denison[1]

Illustrated with Diagram

ABSTRACT

INASMUCH as the heat or power developed by any fuel or combustible compound depends on the rate of flame propagation through the mixture, to increase the power and efficiency of present types of internal-combustion engine, the rate of flame propagation must be increased. Improvements in production engines to date have resulted primarily from modifications of the engine. Although the burning characteristics of conventional and low-priced fuels have received attention, nothing, with the exception of the heating of the hot-spot, has changed the conditions of the delivering and mixing of the charge during the last 20 years.

Without giving consideration to the physical or chemical composition of the various fuel compounds in use and without attempting to reconcile the results obtained with some of the published results derived from the mathematical analyses of combustion chemistry, the author gives some observations and conclusions deduced from a series of experiments carried on under conditions under which practical results and careful study in an endeavor to correlate the phenomena were all that could be obtained.

The fuels studied were distillates, 32 to 36-deg. Baumé fuel oil, 40 to 41-deg. fuel oil, an unrefined kerosene, a 58-deg. gasoline with from 25 to 27 per cent of benzol added and a 68 to 70-deg. straight-run gasoline. In this study, two engines of special and similar design were used, in which first consideration was given to a thorough mechanical mixing of the fuel and the air previously to ignition, the fuel being handled by a liquid-fuel injection-system without preheating either the fuel or the air. These tests are said to be the first successful handling of high and low-gravity fuels without preheating in an engine having low compression and electrical ignition.

The general conclusions reached are that the rate of flame propagation through an optimum fuel-air mixture varies (*a*) probably directly with the physical mixture condition of the fuel and the air at the time of ignition, (*b*) very slowly within certain limits with different grades of fuel and (*c*) very slowly with the condition of the fuel at the moment of ignition, that is, little difference seems to exist between the fuel in a vaporized state and that in a foglike condition, provided the fuel and the air have been well mixed; (*d*) with different compression pressures, it varies in a manner that cannot definitely be stated; (*e*) very much higher rates of flame propagation than are being obtained in present engines seem to be an inherent property of the fuels now in common use and (*f*) the weakest link in present engines is the fuel-distribution system.

Although carbureter development has reached a high degree of efficiency in measuring the fuel charge per intake-stroke, it is not known how much of the fuel delivered by the jets during a given intake-stroke reaches the cylinder nor what proportion of a given fuel-charge is thrown out of the air-stream at the manifold bends, the fuel being carried back and forth in the manifold by the reversing air-flow and portions of it being dragged into any cylinder by the friction of the air. If the conditions existing in a manifold are of this description, it would be easy in the opinion of the author, to account for the low efficiency of gasoline engines and to work out a simple theory as to the cause of detonation.

THE useful heat or power developed by any fuel or combustible compound depends on the rate of flame propagation through the mixture. All attempts to increase the power and the efficiency of existing types of internal-combustion engine must result in engines in which the rate of flame propagation through the mixture is at a higher rate than that existing at the present time. The spread of the flame-front from the ignition source must be at a uniform or increasing rate of velocity as it passes through the fuel charge, thus obtaining complete chemical transformation during the period of minimum wall-exposure during the stroke.

Some of the methods now being employed to increase this rate and also the power-output and fuel-economy include: (*a*) the Ricardo type of combustion-chamber, (*b*) higher compression, (*c*) special fuel compounds, among which are high-test gasolines and anhydrous alcohol mixtures, (*d*) ethyl mixtures and (*e*) special wall-coatings on the combustion-chamber that have a catalytic action.

The general effect of these methods has resulted in an all-around improved performance. The statement may be made, however, that it is doubtful whether present types of four-cycle engine can be developed to a materially higher standard in view of certain fundamental deficiencies. One of these is the dilution of each fresh charge of fuel-mixture with exhaust products equal in volume to that of the combustion-chamber at approximately atmospheric pressure, and the effect of this dilution on volumetric efficiency, flame propagation and heat absorption. Engineers may have noticed that the amount of spark-advance required has decreased little, if any, through the use of the above-mentioned improvements for the spark-advance required is really a measure of the inflammability of the charge. A condition of interest, so termed while proof is lacking of its being a deficiency, is that of obtaining a good physical mixing of the fuel and the air above the carbureter venturi and of maintaining this condition during the pulsations and reversals of direction that occur in both the manifold and the cylinder. The tendency of a given cylinder charge is to take the shortest possible path to the seat of the depression in the cylinder. In the manifold, the inertia of a liquid-fuel globule may throw it out of the stream at a bend and, if it enters the cylinder, may cause it to be deposited on and adhere to the piston-head. Thus, mixing is upset and combustion is affected.

As the characteristics of a production engine operating on the different fuel grades and compounds offered by refiners and dealers throughout the country are of first importance, it would seem that the improvements to date result primarily from modifications of the engine. The burning characteristics of conventional and low-

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priced fuels are a study that has received considerable attention, but nothing is on record to show that further increase in power-output or fuel-economy is being obtained by improving the burning properties of the fuel mixture. Except for "hot-spot" heating and the effect of the Ricardo combustion-chamber in promoting turbulence and, consequently, better mixing in the cylinder, the conditions of the delivering and mixing of the charge have remained unchanged for the last 20 years.

Practical Results Sought

It is proposed to give herewith the observations and conclusions derived from a series of experiments that have been carried on under conditions under which practical results and careful study to correlate the various phenomena were all that could be obtained. It was not possible and later was found to be apparently unnecessary to consider the chemical or physical make-up of the various fuel compounds in use. No attempt has been made to reconcile these observations or conclusions with the results of some of the mathematical analyses of combustion chemistry that have been published. This is reserved for the future, as much more work and equipment will be required.

The fuel grades under study were distillates, 32 to 36-deg. Baumé fuel oil, 40 to 41-deg. fuel oil, an unrefined kerosene, a 58-deg. gasoline with from 25 to 27 per cent of benzol added, and a 68 to 70-deg. straight-run gasoline. These fuels were studied in two engines of special and similar design, in which a thorough mechanical mixing of the fuel and air previously to ignition was the first consideration. The fuel was handled by a liquid-fuel injection-system, without preheating either the fuel or the air. One engine had 45-lb. per sq. in. compression-pressure and the other 53 lb. per sq. in. at the cranking speed, 125 r.p.m. The ignition-systems of both engines were conventional, a 6-volt Delco battery-system on the former, and an Eisemann high-tension magneto on the other. It was possible to change at will from any one to any other of these fuels, and the power output varied practically in proportion to the heating value of the fuel used. Using the fuel oil, the engine started readily, while both were at the average room-temperature, about 65 deg. fahr., at an engine speed of from 250 to 300 r.p.m.

Fuels Used Without Preheating

These tests appear to be the first successful handling of high and low-gravity fuels without preheating, in an engine having low compression and electrical ignition. During the runs, the spark-advance required has not been more than 15 deg. The engines used were of the two-stroke-cycle type, with the exhaust-port at the bottom of the stroke, thus limiting the expansion and exhaust strokes to some 60 per cent of the angular-movement of the crankshaft found in four-cycle engines and with the consequent rapid exhaust-valve opening obtained from ports controlled by a crank motion. No indication was apparent that combustion took place outside the cylinder. Regardless of the speed or the throttle opening, all that could be seen was a small cone of flame of very low luminosity, when the exhaust-manifold was removed. This small degree of spark-advance and almost flameless exhaust would indicate very desirable characteristics, namely, a high rate of flame propagation through the mixture and complete combustion during a small crank-angle period.

Although compression pressures have been given at conventional cranking-speeds, the Bourdon-tube gage employed for compression-pressure measurements showed 75 lb. per sq. in. at 400 r.p.m. Certain features of the engine design accounted for this increase. The compression pressures at speeds higher than this were not investigated. It is believed that the building-up of the compression pressure with the speed places the engines in a position for direct comparison with conventional four-cycle engines on a compression basis.

In several of the papers[2] presented by Thomas Midgley, Jr., manographic studies of kerosene as a fuel have been given. In each of them the so-called characteristic detonation knocks appear; these, when the fuel was burned in four-cycle engines, he has termed the "signature" of the fuel. In the experiments mentioned herein, in which both kerosene and lower and heavier grades of fuel were used, there has never been a trace of this so-called detonation.

Saw-Tooth Effect of Expansion Curve

One unusual feature of the manographic cards, however, is a pronounced saw-tooth effect on the expansion curve when it is taken on a pressure-time basis. The pressure variations are about 40 lb. in magnitude and the mean wave-length about 1.25 to 1.50 times the height. The long wave-length, together with the combustion characteristics, as observed, would indicate a relatively slow wave-motion acting on the instrument. These are thought to be caused by pressure waves, reflected between the piston and the cylinder-head, that die out at about the middle of the stroke. Although they may be caused by the natural period of the indicator mechanism, this is not believed to be so, on account of the time or the distance during which they are visible and the total range of pressure variation during the first half of the expansion stroke. They are, therefore, considered to be a record of true pressure-waves and their magnitude to be proportional, in some degree, to the rate of flame propagation throughout the mixture that sets them up.

Rate of Flame Propagation

Very few data concerning the rates of flame propagation are on record. One paper[3] appeared that showed an elaborate set-up of electrical instruments for obtaining measurements, by measuring the time required for ionization of the gas from one spark-plug to another in a conventional four-cycle engine. At 1400 r.p.m., the average high rate, without detonation, was given as 41.27 ft. per sec. The conditions were a mixture-ratio of 12 to 1, with a 30-deg. spark-advance, standard "X" gasoline, and full throttle-opening. In a practical view of what is considered an explosion, this seems an absurdly low rate when its velocity is compared with that of others, such as the intake velocity through the same engine at the same speed. In the 53-lb. per sq. in. compression-engine previously mentioned, the firing-cylinder dimensions were 4⅝ x 7 in. The engine design included scavenging as a functional process. The nominal compression of 53 lb. per sq. in. has been built up to more than 575 lb. per sq. in., maximum pressure, in 15-deg. crank-angle at an engine speed of 500 r.p.m. This was obtained with the gasoline-benzol mixture. It must be remembered that the low compression-pressure, a 3 to 1 ratio, required a very large combustion-chamber. With a rough calculation, the flame velocity was computed to be 85 ft. per sec.

This is twice as high as that noted above and at almost one-third the engine speed. The maximum-pressure

[2] See The Journal, December, 1920, p. 489; June, 1922, p. 451; and February, 1924, p. 182.

[3] See The Journal, February, 1920, p. 119.

figure given is the mean of many observations with the Midgley indicator, in which the deflection of the spot of light, with an indicator-spring calibrated at 200 lb. for ¾-in. movement, was measured. A remarkable condition is the high ratio of the maximum to the compression pressure.

Flame-Propagation Rates in Four-Cycle Engines

Flame-propagation rates in use in engines of the four-cycle type lead to some interesting conclusions. When using straight gasoline or benzol mixtures as fuel, ignition-timing near the dead-center is required for full-throttle low engine or car-speed. As the car-speed increases to about 18 or 20 m.p.h., the control may be moved to the normal fully advanced position of from 25 to 30 deg. With this angular-advance for a given range in engine speed, it would seem that engines having maximum speeds of from 4000 to 5000 r.p.m. would require proportional ignition-timing advance. If this were so, the spark would take place somewhere between the lower dead-center and the closing of the inlet-valve.

On some late-model engines, the compressions of which have been increased, and in which the owner finds the combustion-controlling properties of ethyl gasoline to be advantageous, the spark may be carried at full advance, regardless of the speed of the engine or of the car. This leads to the conclusion that, at least above some critical speed, the flame-propagation rate varies directly with the speed.

It has not been possible to include herein a comparison of the flame rates through fuel oils with the rate obtained through the gasoline-benzol mixture. It is believed that the rates are at least 35 per cent lower. The phenomenon leading to this conclusion was that a much greater amount of heat was radiated from the exhaust pipe. The clean and almost flameless exhaust would indicate this figure to be a very conservative estimate.

If further investigation should show that this figure should be increased, there would still be a wide margin before the rate through the well-mixed charge of cold fuel-oil and air would drop as low as that through the gasoline mixture in the four-cycle engine. The comparison figures are 55.00 ft. per sec. at about 1000 r.p.m. with 15-deg. spark-advance for the fuel oil, as against 41.27 ft. per sec. at 1400 r.p.m. with 30-deg. spark-advance for the gasoline fuel.

Function of Flame Propagation

The deductions and conclusions given herein, being the result of practical rather than thorough scientific methods of determination, do not materially affect the issue. The function of the rate of flame propagation is to enable the mixture to be burned in the least possible time. The smaller the time-interval of burning, the less will be the heat absorbed and the greater will be the pressure available for acting on the piston during the expansion stroke; the useful power will thus be increased. If flame-propagation rates did not vary with the engine speed in four-cycle engines, this principle of engine design would be limited to a very narrow speed-range, instead of the wide range with proportionate power-output that is now obtained.

Two facts, then, stand out that: (*a*) conventional mixtures will burn with much greater velocity than is now being obtained at low or reasonable speeds in production engines; I believe that this is due to the charge mixing in the manifold and in the cylinder improving with the speed and (*b*) a very wide margin exists between the present normal rates of flame propagation and those which are too high for use, through detonation or other undesirable effects on the engine. Since engines will run at speeds in excess of 5000 r.p.m., with a proportionately high power-output, it would seem that it should be possible to obtain considerable improvement in power and fuel economy by obtaining or utilizing a mixture condition at the moderate speeds at which these high burning-rates can be employed. Although, as is to be expected, the results to date show a lower burning-rate for the heavy oils, they also show a comfortable margin between the velocity now being obtained in four-cycle engines and that which is possible as an inherent property of any fuel suitable for use in existing types of internal-combustion engine.

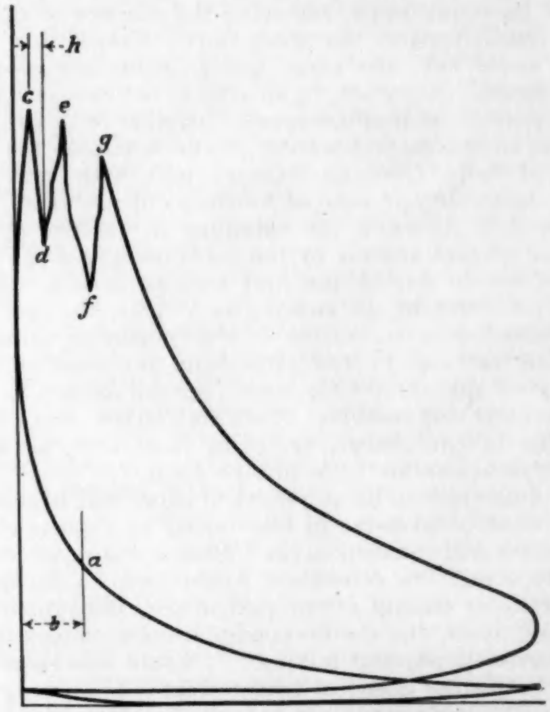

Fig. 1—Indicator-Card from an Engine Suffering from Detonation

If the Entire Mixture Could Burn Uniformly, Following the Passage of the Electric Ignition-Spark, the Pressure Rise Indicated by the Lines *d* to *e* and *f* to *g* Could Not Take Place; Hence, Detonation Would Be Eliminated

Cause of Detonation

Another result of these experiments is that it warrants definite conclusions being drawn as to the cause of so-called detonation phenomena. Let the diagram in Fig. 1 be illustrative of that obtained from an engine suffering from detonation. Let *a* represent the ignition of the mixture in the orthodox manner through the medium of the spark-plug, with the conventional 25 to 30-deg. advance. The distance of piston travel *b*, from the point of ignition to the top dead-center, represents merely a time or angular interval, and in that interval sufficient fuel is burned to develop the pressure shown by the peak *c*. At the point *c* something happened; some condition stopped further flame-propagation. The almost vertical drop in the cylinder-pressure record shows that evolution of heat had ceased and that cooling was rapidly reducing the temperature of the whole mixture. Yet the mean temperature of the whole mass of gas within the cylinder must have been far above the temperature of self-ignition.

At the point *d* flame propagation or burning again began, as is evidenced by another rising line from *d* to *e*. It would seem that the time-interval from the peak

c to the point *d*, in connection with the heat and pressure conditions within the cylinder, had the effect on the remaining unburned mixture, or some portion thereof, of creating a condition capable of supporting a high rate of flame propagation for a very brief space of time. Thus, a heat-evolution cycle entirely separate from that of the ignition of the charge, was set-up.

Detonation in Four-Cycle Engines

Two theories may be advanced to explain the action in this four-cycle-engine cylinder diagram during the combustion-period. It is obvious that, if the entire mixture could burn uniformly, following the passage of the electric ignition-spark, the pressure-rise lines *d* to *e* and *f* to *g* could not take place, hence, detonation would be eliminated. Moreover, in an engine not detonating, the time-element at medium speeds, together with the effect of the engine cooling-system, should eliminate the emission of flame from the exhaust port with more than faint luminosity if delayed burning did not exist.

The first theory is the obtaining of further physical mixing of fuel and air by the pressure waves and flame waves set up during the first burning-period, together with the effect of the changes in volume, the result being agitation or turbulence of the remaining dense fuel and air sections of the remaining unburned mixture, giving an opportunity for more fuel and oxygen to come into contact and combine. This may either complete the burning of the charge, or, as is illustrated, allow another heat-evolution cycle to take place.

No data seem to be on record to show that heat-evolution cycles, progressive in their order as illustrated, can take place without detonation. When a four-cycle engine is detonating, the detonation would seem to depend on the grade or quality of the fuel in use, the proportions of heavy ends, the compression-pressures employed and the degree of physical mixing. It would also seem possible that actual chemical transformations, forming new combustible compounds, can take place before all the fuel has been consumed.

The words chemical transformation are used in the sense that the first evolution of heat and pressure had changed the proportions of hydrogen and carbon in the molecules of some portion of the unburned fuel, for which the time-period *h* was apparently necessary or allowed it to take place. In support of the chemical-transformation theory, it may be of interest to mention briefly some results of other investigations into hydrocarbons. Vivian B. Lewes, in a study of ordinary illuminating gas in open gas-jets, found that acetylene is formed and then decomposed. At the point at which luminosity begins, some 70 to 80 per cent of the compounds formed is acetylene, whereas the original gas contained less than 1 per cent. Immediately above this point, the increasing heat breaks up the acetylene; the hydrogen burns freely, while most of the carbon is heated to incandescence by the combined influence of the burning hydrogen and the latent heat of the chemical separation. Illuminating gas is chemically different from a paraffin vapor, but all hydrocarbons are complex compounds that are very unstable under conditions of high temperature.

Cracking processes for increasing the quantity of gasoline obtained from heavy oils are well known and are in extensive commercial use. Briefly, they consist of subjecting the heavy oil to certain temperatures and pressures under which some large fuel molecules will break up into smaller ones. In the engine-cylinder, following the heat-evolution cycle of ignition as illustrated, the actual pressure-conditions compare favorably with cracking-still pressures, whereas the temperature is many times greater. No method is yet available for studying the behavior of hydrocarbon fuel-mixtures, from the standpoint of the cracking or molecular changes, as they take place in the engine-cylinder at temperatures close to 3000 deg. fahr. behind an iron veil, and in time-intervals of small fractions of a second. Chemically, the splitting-up of a large molecule of a paraffin product, as in the cracking process, could free three smaller molecules, two of which could be paraffin and the third acetylene.

Some investigators believe that they have obtained spectroscopic evidence of acetylene explosions in an engine in which detonation was taking place. Others believe that free hydrogen may be evolved or liberated during the combustion process, which, when combined with oxygen, would also have a high burning-rate. Due to the very nature of the combustion process, to the physical and chemical changes that a given portion of the fuel undergoes and to the high velocity or the brief time-interval between the carbureter jet and the exhaust port, considerable work remains to be accomplished before the conditions in the cylinder during combustion will be well understood.

Detonation a Symptom of Mixture Condition

This analysis justifies the conclusion that detonation is a symptom primarily of a mixture condition that will not support a uniform rate of flame propagation; and that, although the air and the fuel have been mingled, their physical condition seems to approximate that of the sand, stone and cement lying in a hopper before being fed into a concrete mixer.

When considering that the rate of flame propagation obtained is low, that the burning may extend over some 360 deg. of crank movement and that the fuel either passes through the engine unburned or burns after it leaves the exhaust-valve, as is the case in an average engine, the conclusion is justified that, with the present physical condition of mixtures, the combustion process, when detonation is absent, is a slow steady or spasmodic burning, in which pressure waves, the effect of piston motion and the energy liberated by the chemical transformation of each atom act as forms of fuel supply to bring more fuel and oxygen into contact. What has been considered as having been accomplished before combustion is completed through turbulence during combustion. With increasing compression-pressures, a critical point seems to be reached at which the initial combustion-wave is great enough so that, if heavy fuels are used and cracking can take place, the characteristic detonation phenomenon will appear.

The high ratio of the compression to the maximum pressures obtained in the special engines that have been mentioned and the small degree of spark-advance required are considered to be caused by a mixture condition in which the oxygen and the fuel were thoroughly mixed mechanically before ignition. This enabled the fuel charge to burn at a high and uniform rate or at an increasing rate because the pressure from the flame-front increased the compression of the unburned portions of the mixture.

Nothing can be said at the present time about the effect of higher compression-pressures when the fuel charges are in a thoroughly mixed state mechanically or about the possible limit of suitable flame-propagation rates at moderate speeds. The existing data on flame rates during detonation would seem to indicate that it is

possible for hydrocarbon compounds to burn with a rate approaching that of true detonating, that is, nitrated compounds. Engineers, however, are well aware that pure research and practical results are arbitrarily given separate and distinct commercial ratings.

Most Previous Studies Confined to Physical Phenomenon

Most of the studies of detonation on record to date seem to have been confined to a study of the physical phenomenon. Nothing seems to be on record regarding an investigation over the widest possible speed-range with a fuel that is known to cause detonation at some given speed or over some given speed-range. It is possible for two conditions to exist here. One of these is a disappearance of the phenomenon at some high speed because of the extremely short time of the power stroke and the better quality of the fuel-charge mixing in the manifold, as before mentioned. The other is, that with the greater heat and pressure obtained, because of less heat absorption at high speed, the chemical-transformation rate, creating a fuel condition that will cause detonation, will be accelerated.

Many authorities agree that a considerable portion of the fuel passes unburned through the average four-cycle engine. All agree that carbon monoxide in the exhaust is a direct indication of wasted fuel. It is apparent, from the amount of monoxide in the air on streets carrying heavy motor-vehicle traffic, by the experience in a Pittsburgh tunnel last spring and by the greatly increased provision for ventilation in the Hudson River vehicle tubes, that the emission of this poisonous gas is a serious factor. The theory has been advanced[4] that some motor-vehicle accidents may be caused by carbon-monoxide poisoning, exposure to the fumes causing partial unconsciousness or temporary irresponsibility.

The engines that have been mentioned, from the action of which this theory has been worked out, have been operated for hours under full throttle with different grades of fuel in a laboratory that measures 60 x 100 ft. The partitions are about 7 ft. high. No blower or forced-ventilation system was used, the only air-circulation being obtained by opening the windows and doors. With the engines exhausting directly into the room, members of the organization during the runs have breathed what would seem to be highly contaminated air until the slow natural circulation had removed the exhaust products. No complaint because of ill effects from this exposure has been received and I am satisfied that with a thorough physical mixing of the fuel charge, the formation and emission of carbon monoxide will be prevented.

Uniformity of Fuel Composition Essential

The application to the internal-combustion engine of the theory here presented may open a new avenue for research and design, but from the standpoint of general industrial conditions it is a well-known requirement. Brief mention may be made of the absolute necessity for uniformity in the composition and the mixture of the powder charges for big guns. Here, a lack of proper mixing, giving either slow or abnormally high rates of flame propagation and pressure evolution, would nullify the most careful range finding and sighting. In industrial applications, it has been found that powdered coal, blown into the kilns under air pressure, is the most practical and economical method of making Portland cement. In the city of Cleveland, considerable publicity has been given to a method of handling fuel in a new heating-plant recently put into operation. Reports state that 90 per cent of the fuel is passed through a 200-mesh screen and that nothing too coarse to pass through a 100-mesh screen is used. The fuel is blown into the combustion-chamber with air pressure; and the efficiency is given as three or four times as great as that obtained by throwing in lumps of coal.

This system would indicate that the first consideration for efficient heat-evolution is that the fuel shall be in a reasonably fine state of subdivision and that the supply of air to provide oxygen shall be ample. Within certain limits and with due regard to the purpose for which the fuel is used and the rate or nature of the combustion desired, it would seem that the actual size of the fuel particles does not matter. The probable explanation of this feature is that, as the atoms on the outside layer of a large fuel molecule are ionized, the energy liberated detaches them from the parent molecule. They are swept out of the way and fresh oxygen is carried in atom by atom, by the forces and movements set-up by the action of the chemical transformation and by the various other actions and movements that take place. The conditions in the boiler or the kiln may lack the conditions of pressure due to the compression existing in an internal-combustion-engine cylinder but the natures of the combustion are so similar in these cases that they are suitable examples to use in support of this theory of fuel-charge mixing.

[4] See *Automotive Industries*, Sept., 18, 1924, p. 533.

A SCHOOL OF SINCERITY

SCIENCE is the most intimate school of resignation and humility, for it teaches us to bow before the seemingly most insignificant facts. It teaches us, in effect, to submit our reason to the truth and to know and judge things as they are; that is, as they themselves choose to be and not as we would have them be. In a religiously scientific investigation, it is the data of reality themselves, the perceptions we receive from the outside world, that formulate themselves in our mind as laws; it is not we who formulate them. It is the numbers themselves which in our mind create mathematics.—Miguel de Unamuno.

Progressive Maintenance

By FRED M. SHARP[1]

IT is a sorry sight in many factories; yes, in the majority of factories, to find the apparent disregard for equipment, from the standpoint of up-to-date progressive maintenance. Some will ask what constitutes progressive maintenance; and to best define the term I will refer to a question that was asked a superintendent of maintenance by the general manager of a large and successful manufacturing plant.

"Say, John, our records of your department for a number of years back show a consistent reduction in the cost of our equipment and factory maintenance. It is a puzzle to me, for we employ double the number of men and have increased our operating equipment nearly 80 per cent; and much of it has seen long years of service. Your department seems to accomplish the impossible and maintain a higher standard of efficiency and durability, at less cost. Tell me how you have obtained this result."

John looked up at his boss, and with a happy expression answered: "It is progressive maintenance. When I came to your office 9 years ago, Mr. Clare, seeking a job, you placed me in the department of which I am now the head. At first things looked mighty blue and the old story, lack of interest, kept me from accomplishing much. The department was classed as a nonproductive one and looked upon as a necessary evil; something that had to be tolerated. Those in it were given no authority. I could not see things from that viewpoint and the old slipshod method of: 'that's good enough,' did not appeal to me.

"I attempted to interest my superiors in what I felt certain were the proper methods to be employed in handling the problems under my supervision. They would listen to my ideas up to the point where the cost of some new installation or a change in routine became involved. Then the shoe pinched. No considerable amount of money could be secured for improvements. So, the old way of 'fix it up for the present' was the answer. Finally, becoming thoroughly dissatisfied, I went to your office and tendered my resignation. You asked the circumstances causing me to make the decision and in a very few words I explained my desires and ambitions. You did not fall in line with all my ideas but promised me your support, along several lines of progression. I was very pleased at the outlook and remained with you.

"Then the fun began. Fun! yes, new stimulus, derived from seeing new ideas born, prejudices overcome, interest manifested and real cooperation secured. You repeatedly extended your support to me, when the crowd leaned the other way. New ideas were inaugurated continually, though only a limited number of them were carried through; until interest and cooperation fell in line. It was all gradually accomplished. Get-together meetings were held, and they were well attended.

"Anticipation and prevention of wear-and-tear or further breakage were topics often discussed and constantly practised. For example, if we found a certain drive-shaft in a machine breaking frequently or a bearing wearing out too often, the fact was brought up in a meeting and discussed, and remedies were suggested. An analysis of the steel was at times recommended and made, and a better grade was substituted; sometimes a simple heat-treatment overcame the trouble; or we tried another make of bearing better suited to meeting the special service. Occasionally we found that the fault lay in the original design being too light for the shock-load or the speed to which the part was subjected. At times a different composition of bearing metal brought about desired results.

"I always remembered that a constant effort must be made to overcome and end any trouble. And then, you know what happened; for instance, to Bill La Corse, who used to run that 18-in. engine lathe in the machine repair department. You remember how busy he was always kept making shafts and bearings for that battery of pesky automatics. Bill lost his job, and down went the cost of maintaining that department; resulting in pleased operators, foremen and department superintendent. That created a sincere desire in the department to make a showing; to cut down its overhead still more.

"Yes, sir! Ideas were stimulated daily, more personal interest was shown, and better cooperation was evident in the whole organization. Of course, every idea advanced did not prove a howling success, but the birth-rate was so high in this particular community that we were not seriously affected by a few ideas slipping away, even after they were pretty well grown.

"At our weekly get-together meetings a list of all breakages of equipment and tools, of trouble caused by lack of oil and damage done to pipe-lines or sewers, plant lighting and buildings, in fact, of every damage sustained throughout the plant during the previous week, was presented and considered. Each item on the list was touched upon briefly, to bring the matter to the attention of everyone present. There was a general understanding why this was done. The reasons were these:

(1) To find out, so far as possible, the cause of each individual trouble or mishap
(2) To endeavor, if possible, to prevent a recurrence of the trouble

"That sounds simple, does it not? To locate the cause and then apply a preventive. The locating of the cause is usually a simple matter compared to preventing a recurrence. Having found a preventive, we tried persuasion to secure its use. Failing to obtain cooperation, we issued strict orders what to do and what not to do; at times we discharged workmen or replaced supervising foremen or, still more strenuous, discharged or transferred a department superintendent. The task became harder every minute, but the firm resolve to attain our goal sent us back to read the second clause in our preventive line-up:

> Endeavor, if possible, to prevent a recurrence of any trouble. To attain a desired end, our motto is, 'Be just and honorable.' Give everyone concerned a fair chance, but remember we are instituting progressive maintenance. Although fairness and justice rule, there can be no place for weak knees

"I have outlined the processes that were used to get

[1] Assistant works engineer, Oakland Motor Car Co., Pontiac, Mich.

the results you have found reflected by the reports. The main points I am anxious to make clear are:

(1) Deliberate indifference or neglect ruins anything
(2) Care, intelligently applied, improves anything
(3) Indifference means continual loss
(4) Manifested interest, brains and cooperation overcome mighty difficulties

"Another custom we have always adhered to is never to under-estimate a workman's ideas or suggestions. Very frequently those suggestions concern the things that the seniors would never think of. A workman, unknown, may through suggestions bring great credit to his senior and much benefit to the company.

"Many manufacturers, when passing through our plant have wondered why our machinery and buildings appeared to be kept in better condition than theirs. To them I would say: 'Analyze the question. Have you given the individual in charge of the upkeep of your property cooperation in planning full support in execution and the authority he needs to win this contest for you? Deprived of any one of these, he is powerless to accomplish the results you pay for and never get.'

"Many would probably answer the question: 'It's my own fault; I have not given the necessary support. Instead, I have growled about excessive costs. All through my plant we drift along from day to day, allowing fine equipment to run down, sapping organization and production and giving the impression generally that the maintenance department is a millstone around the neck of the productive units. I am firmly convinced that in reality progressive maintenance is a prime factor and vital in the successful operation of any industry.'"

J. J. COLE

AFTER having been in uncertain health for the last two years, J. J. Cole, president of thhe Cole Motor Car Co., was stricken with a heart attack and died at his home in Indianapolis on Aug. 5, 1925, aged 56 years. He was born on March 23, 1869, at Connersville, Ind., and was educated at the Connersville High School. As a young man, he came to Indianapolis to enter the service of the Parry Mfg. Co., builder of carriages and road carts. Later, he was associated with the Moon Carriage Co., St. Louis, as sales manager, becoming secretary of the company before he resigned to establish the Cole Carriage Co. For 35 years prior to his entry into the automobile industry he was a leading figure in the carriage business.

Following the establishment of his own business, Mr. Cole continued to give it his entire attention for the remainder of his life. The first car of the Cole Motor Car Co. was built in 1908, and the Cole Company reached its peak of fame in the industry in 1921 when it maintained approximately 1000 dealer connections. However, Mr. Cole was a believer in small-scale business, having the close personal supervision of its chief executive and the company did not attain what is considered to be large-scale production.

The affability and capacity for human understanding possessed by Mr. Cole endeared him to his associates and friends throughout his life. He held membership in several clubs and was a member of the National Manufacturers Association of America. On Nov. 20, 1911, he was elected to Associate Membership grade in the Society.

ARTHUR M. DEAN

A SLIGHT accident, sustained while in his sailboat on Long Island Sound, resulted later in an infection that caused the death of Arthur Malcolm Dean on July 4, 1925, aged 42 years. He was born at Pembroke, Mass., on Oct. 25, 1882, and received his preliminary education at the Canton, Mass., High School. Graduating in 1905 from the Massachusetts Institute of Technology as a mechanical engineer, he became assistant superintendent for the Pope Mfg. Co., Hagerstown, Md., resigning in 1907. For the next two years he was experimental engineer for the Mora Motor Car Co. and in 1909 became chief engineer of the Matheson Motor Car Co., Wilkes-Barre, Pa. Subsequent to 1914 he was assistant engineer of the Ferro Machine & Foundry Co., chief engineer of the Templar Motor Car Co., and was associated with the activities of the Rubay and of the Swan Carbureter companies, all of Cleveland, up to 1924 when he became connected with the General Chemical Co., New York City, as chief engineer and was actively engaged in this capacity at the time of his death.

Mr. Dean's specialty for the last 4 years was the design and construction of a small marine-type Diesel engine, and he had developed the engine so that it was about ready for factory production.

He was a member of the American Society of Mechanical Engineers and was elected to Member grade in the Society of Automotive Engineers on July 12, 1910.

HARRY UNWIN

UNWELCOME news recently conveyed is to the effect that Harry Unwin, widely known because of his lengthy association with the varied activities of the automotive industry, died suddenly of angina pectoris in the Fort Pitt Hotel, Pittsburgh, on July 29, 1925, aged 57 years. He was born at Cambridge, England, June 4, 1868, but became a citizen of the United States. His education was received mainly in the school of experience, and he had been actively interested in numerous phases of the automobile business for 25 years previous to his death.

For the greater portion of his automotive career he was associated with retailing, but in 1911 was elected president and general manager of the Morgan Motor Truck Co., Worcester, Mass., and at another time was secretary of the old National Association of Automobile Manufacturers. His military title was acquired during the war, when he was instrumental in organizing the purchase of spare parts for automobiles used in the service.

In 1919, Mr. Unwin was elected vice-president and general manager of the Reo Motor Car Co., of Chicago, and lately had been connected with the Chrysler Motor Car Corporation in charge of fleet sales development work. He was elected to Associate Member grade in the Society on Oct. 7, 1919. He is survived by his wife and two children.

The Budget System as an Aid to Service-Station Management

By J. E. Mills[1]

Service Meeting Paper *Illustrated with* Charts

ABSTRACT

SUCCESSFUL operation of a general service-station depends upon the application of several business fundamentals. The service division of a car sales organization can be made to produce a fair profit by following proper methods, but the importance of the service division as a possible asset or liability has only recently begun to be recognized by the more progressive sales companies; surprisingly few service-station operators or managers have attempted to study the condition and to correct faults and increase the efficiency of their shops, while fewer still have any definite control-records for their guidance. Too many organizations try to conduct their service divisions with little or no attempt to follow the business principles that are observed by the foremost corporations in many lines of industry, with the inevitable result that the monthly balance sheets of the service-stations vary from a heavy loss to a fortunate profit.

The author regards 8 per cent as a fair profit, realizing that the main source of profit of a distributer or dealer is the sale of new vehicles and that, as good service helps to increase such sales, any income from the service division, above its expenses and in excess of a fair profit, should be used to develop better service or to reduce certain costs of service to the car-owners. Successful distributers and dealers are careful to employ, as managers of their service-stations, experienced business executives who can direct men and who also have some knowledge of shop practice. They put business training first in importance and mechanical knowledge second, thus reversing the practice of the past. The main requirements of good service are cleanliness in and about the premises; prompt, courteous and friendly reception and treatment of customers; definite promises of delivery dates made and kept; prompt, careful and correct workmanship; standardized prices; correct billing, and avoidance of disputes.

Application of the budget system to the business is advocated as a sure means of conducting it on a sound basis. The budget determines as nearly as possible, after consideration of all factors, including the previous year's business, the volume of income that should be expected for the current year and apportions it by months. It fixes the profit desired and the balance of income that can be allowed for all items of expense. It sets a goal to be reached and establishes a definite basis for the guidance of the management.

The method of preparing a budget is explained in detail and tables for a budget of $36,000 for 1 year are given. In one table the major items of income, gross cost of doing business and gross and net profit are apportioned by months throughout the year. Similarly, all items of direct expense, from which no revenue is derived, are listed and allocated by months in the same proportions as the income. By adhering to such a table, the expenses are kept in balance with the income month by month. In making up a budget, the desired net profit should be deducted from income before deducting the total direct expense of conducting the business, in the opinion of the author, thereby placing a greater check on expenditures and more nearly ensuring the profitable management of the business. Various items of direct expense are explained.

Methods of control for adhering closely to the budget day by day throughout the year are described and illustrated with charts. They involve the centering of authority for all expenditures in some one individual and the keeping of records of all items of expense for each shop in the service division, of all idle time, all billing for service rendered, all productive hours of work and a register of car-owners that shows the frequency and kinds of work rendered for each customer. Such records present a current picture of the progress of the business with relation to the budget and to the previous year or years and are essential for the information and guidance of the service manager. Keeping and posting such records is delegated to a stenographer and does not require altogether an average of more than 2 hr. of her time per day.

DAY by day I am more firmly convinced of the importance of the proper servicing of motor cars and trucks in a mechanical way and, what is more important, the operation of the service department on a business basis. The successful operation of a general service-station, whether it serves one particular make of car or truck or a number of makes, depends upon several fundamentals. Some of these are well known and observed in practice, yet it is surprising how few service managers or service-station operators have even attempted to make a study of the conditions in their stations and to correct faults and increase the efficiency of their shops. Even fewer have any definite control-records for their guidance.

Efficient and profitable operation of the service department or division of a car sales organization is the natural desire, but too many organizations try to conduct their service divisions with little or no attempt to follow those principles of business that are observed by the foremost corporations in many lines of industry, with the inevitable result that the monthly balance sheets of the service divisions vary from a heavy loss to a fortunate profit. This condition is due to the fact that the service division and its personnel have not been considered as carefully by the automobile producers, distributers and dealers as they should be. The service department has only recently been recognized as a real asset or liability to the sales division and to the factory. I believe it has been so recognized only by the more progressive companies, which regard it as a division that should yield a fair profit. By a fair profit I mean not more than 8 per cent, realizing that the main source of profit is the sale of new cars and trucks, and, as good service helps to increase sales, any income above expenses in excess of a fair monetary profit on the operation of the division should be used to develop better service by doing a little more work for the same price, by reducing certain standardized prices that might ap-

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pear to the car-owner to be a little too high, and by employing better personnel. Fair profit can be realized in a service division by following proper methods, provided the type and the location of the building used by the service division are suitable.

Fair Profit Can Be Realized

Successful distributers and dealers, recognizing that a fair profit should and can be realized, that a properly conducted service division induces additional car sales and consummates the transactions of the sales division, are careful to select and employ an experienced business executive as head of the service division, one who, in addition to his business ability, can direct men and has at least a working knowledge of shop practice. Business training comes first and mechanical knowledge second, thus reversing the practice of the past.

Recently I visited nearly 100 dealers and distributers in different parts of the East and it was really pitiful to observe how little attention and constructive thought were given to the proper servicing of vehicles and, even to a lesser degree, to the proper operation of a service-station from the business standpoint. It was taken for granted by many that the service department was a necessary adjunct to the business which must be tolerated, which lost money, which caused dissatisfied owners and from which no real value could be derived. Many of the general managers seemed to think that to install proper control-methods would involve too much detail and were satisfied to go along as in the past. Fortunately, others were very frank and stated that they had excellent shop foremen, that their service managers were splendid mechanics of pleasing personality and, therefore, were successful with their service clientele; but admitted that these managers knew little about the business end. Many detail records are kept that serve no useful purpose but involve work and expense in keeping them. Few records are required in the service division if they are of a kind to assure complete knowledge of how the division is operating as to finances, satisfaction to patrons and subsequent new vehicle sales originating through the service division.

The Principles of Good Service

The main requirements, with which everyone in the service division should be familiar and which are necessary to the building of new business and the retention of old and new customers, are

(1) Cleanliness of building, both inside and out
(2) Prompt greeting of customers
(3) Courteous and friendly spirit
(4) Definite delivery promises made and kept
(5) Prompt, efficient, careful and correct workmanship
(6) Definite standardized prices
(7) Correct billing
(8) Avoidance of arguments

Recognition of the foregoing as principles that are essential to good service and the creation and retention of trade brings us to the consideration of methods that will give exact information as to the business procedure by which the department should be operated.

Application of the Budget System

We have heard considerable about budget systems in business. The more progressive companies have made a careful study of it and operate every department of their business on that plan, but a great many others have not given the time or attention necessary to ascertain the great benefits to be derived from it. A few years ago our Government adopted a budget plan and, as a result, it is reported that so many unnecessary and excessive expenditures were brought to light as to make possible a reduction of over $60,000,000 in appropriations, which will be saved to the taxpayers of the Country.

TABLE 1—SERVICE BUSINESS DERIVED FROM LAST YEAR

Cars, Number	Age, Years	Amount of Service Required	Total
40	5	$50	$2,000
60	4	40	2,400
100	3	70	7,000
150	2	40	6,000
300	1	25	7,500
		Actual	$24,900
		Approximate	$25,000

A budget is a predetermined plan for conducting a business. It determines, as nearly as possible after considering all factors, the amount of business that should be expected for the ensuing year and allocates the volume over the year by months according to seasons and the business done in corresponding months in the past. Based on the amount of business expected, it indicates the profit that may be anticipated and the balance of the income that can be allowed for expenses, the amounts that can be allowed for every item of expense and prorates each item according to the expected business and the seasons in the light of experience. The budget sets a goal that makes the operation of a business a great game, it establishes a definite basis for the guidance of the management and an objective to be attained. Having undertaken the task, it is a genuine satisfaction to see the plan operated successfully and the goal reached.

How a Budget Is Prepared

Attention is directed first to the method of predetermining the total net business for the current year. Referring to Table 1 and assuming that last year's gross business, derived from rendering service on cars as old as 5 years, was approximately $25,000, the question then is, How many cars of each age class were served? By checking the owners' file, it may be found that only a few cars were more than 6 years old and that the volume of service per car was very small. The other cars serviced, let us say, ranged from 40 between 4 and 5 years old to 300 less than 1 year old. These facts having been determined, it is not difficult to ascertain, by checking over a fair number of owners' records, the average amount derived per car in each class and the total received from each age group.

For the current year, the sales division, after considering all factors, including the sale of 300 new cars last year, improvements in the car this year and the general outlook for the business, expects to sell 400 new cars. This means that the service division will be called upon to service 100 more cars in the 1-year class than last year in addition to all but the 5-year cars serviced last

TABLE 2—SERVICE BUSINESS EXPECTED IN PRESENT YEAR

Cars, Number	Age, Years	Amount of Service Required	Total
60	5	$50	$3,000
100	4	40	4,000
150	3	70	10,500
300	2	35	10,500
400[a]	1	20	8,000
		Estimated Business	$36,000

[a] Expected new car sales.

TABLE 3—GENERAL BUDGET FOR THE CURRENT YEAR

Total Service Sales for the Year,		$36,000
Comprised of Three-Fourths Labor, 18,000 Productive Hr. at Retail Labor Rate of $1.50 per hr.	$27,000	
One-Fourth Parts	9,000	
Gross Cost of Doing a $36,000 Business		
18,000 Productive Hr. at Average Labor Cost Rate of 65 Cents	$11,700	
75 Per Cent Cost of $9,000 Parts Sales	6,750	
Total Gross Cost		$18,450
Net Gross Profit, with Which Business Must Be Conducted and a Profit Realized		$17,550
Net Profit Desired, 8 Per Cent on Sales		$2,880
Net Gross After Profit, Amount That Can Be Expended in Conduct of Business		$14,670

year. All of the cars are moved up into the next higher age classification and the 40 5-year-old cars are eliminated. This gives a schedule of expected business as in Table 2. How accurately such an estimate can be made is shown by the fact that in our own organization we estimated a gross business of $420,000 for a recent year and actually performed service amounting to $423,000.

With the business for the year estimated at $36,000, the total should be divided according to months so that the direct expense can be prorated by months in proportion to the expected business for the individual months. The volume of business will, of course, vary considerably from month to month because of climatic conditions, and the proportions will differ in different parts of the Country and possibly with different makes of car. January, for instance, will be rather quiet in Detroit for an expensive make of car but will be a big month in the South or in California, because wealthy owners go South or West during the winter. Last year's business is the best guide for apportioning the current year's expected business by months. If the season is normal and 10 per cent of last year's business was done in April, it should follow that approximately 10 per cent of this year's business should be done in April. The average normal year is the one that should be used as a guide, or the averages of a number of years may be used.

Calculating Gross and Net Profit

Gross profit is the income that remains after the direct cost of producing the sales has been paid, that is, the cost of labor and parts that have become a part of the completed work. Gross profit will vary in different localities because of the differences in labor rates and will vary with differences in parts discounts. Our company uses a basis of 25-per cent discount on parts, but discounts to some dealers or independent service-stations may range from nothing at all to 35 per cent. The percentage of gross profit to total sales, as used in the preparation of the budget, is 48.75, arrived at as shown in Table 3.

The suggested method differs from that in which some budgets are determined, insofar as net profits are concerned. Some men, when they have arrived at the net gross profit on which the business must be operated, proceed at once to list and deduct all expenses, taking what is left as a net profit; but often, when this is done, no profit is left. The desired profit should be deducted first and the remainder used, if absolutely necessary, to pay all of the operating expenses of the business. For this reason, in Table 3 the desired net profit is figured at 8

TABLE 4—DETAILED BUDGET FOR $36,000 FOR THE YEAR, APPORTIONED BY MONTHS AND BY DIRECT EXPENSE ACCOUNTS

		Yearly Budget	Proportion of Each Item to Whole, Per Cent	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.
	Per Cent of Total Sales Per Month			7.10	8.99	8.28	7.84	8.89	8.00	10.16	10.14	7.42	7.56	7.72	7.9
	Total Sales Budget	$36,000		$2,552.40	$3,232.80	$2,977.20	$2,818.80	$3,196.80	$2,880.00	$3,657.60	$3,650.40	$2,671.20	$2,721.60	$2,779.20	$2,862.00
	Gross Profit	17,550	48.75	1,246.05	1,577.75	1,453.14	1,375.92	1,560.20	1,404.00	1,783.08	1,779.67	1,302.21	1,326.78	1,354.85	1,386.45
	Net Profit	2,880	8.00	172.58	458.74	259.95	225.72	389.31	218.80	544.35	636.43	159.06	79.49	147.88	297.87
	Direct Expense	13,960	38.75	1,073.47	1,119.01	1,193.19	1,150.20	1,170.89	1,185.20	1,238.73	1,143.14	1,143.15	1,247.29	1,206.97	1,088.58
	Balance Unused														
1	Miscellaneous Expense	240	1.72	17.02	21.55	19.85	18.79	21.13	19.20	24.38	24.34	17.81	18.14	18.53	19.08
2	Shop Tools	300	2.15	21.27	26.94	24.81	23.49	26.64	24.00	30.48	30.42	22.26	22.68	23.16	23.85
3	Repairs to Machinery and Tools	60	0.42	4.26	5.39	4.97	4.70	5.33	4.80	6.10	6.09	4.45	4.54	4.63	4.74
4	Repairs to Building	120	0.86	8.52	10.78	9.94	9.40	10.66	9.60	12.20	12.18	8.90	9.08	9.26	9.48
5	Power, Light, Heat and Water	600	4.29	30.00	40.00	80.00	90.00	90.00	80.00	80.00	30.00	20.00	20.00	20.00	20.00
6	Errors—Allowances	300	2.15	21.27	26.94	24.81	23.49	26.64	24.00	30.48	30.42	22.26	22.68	23.16	23.85
7	Rent and Insurance	3,900	27.84	325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00	325.00
8	Stationery and Office Supplies	120	0.83	8.52	10.78	9.94	9.40	10.66	9.60	12.20	12.18	8.90	9.08	9.26	9.48
9	Telephone and Telegraph	180	1.29	12.76	16.16	14.89	14.09	15.98	14.40	18.29	18.25	13.36	13.61	13.90	14.31
10	Service Vehicles	180	1.29	12.76	16.16	14.89	14.09	15.98	14.40	18.29	18.25	13.36	13.61	13.90	14.31
11	Receiving and Shipping	180	1.29	12.76	16.16	14.89	14.09	15.98	14.40	18.29	18.25	13.36	13.61	13.90	14.31
39	Inspection	360	2.44	25.52	32.33	29.77	28.19	31.97	28.80	36.58	36.50	26.71	27.22	27.79	28.62
55	General Labor	600	4.28	42.54	53.88	49.62	46.98	53.28	48.00	60.96	60.84	44.52	45.36	46.32	47.70
59	Corrective Labor	300	2.15	21.27	26.94	24.81	23.49	26.64	24.00	30.48	30.42	22.26	22.68	23.16	23.85
65	Idle Time	300	2.15	35.00	15.00	25.00	25.00	15.00	20.00	15.00	15.00	30.00	35.00	35.00	35.00
70	Supervision	3,000	21.40	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00
80	Clerks, Stenographers and Accounting	2,700	19.23	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00
81	Miscellaneous Expense for Vacation	250	1.88	.....	.....	.....	.....	.....	.....	.....	.....	.....	125.00	125.00	.....
82	Advertising	180	1.28	.....	.....	45.00	.....	.....	45.00	45.00	.....	.....	45.00	.....	.....
83	Traveling	75	0.53 any month	.....	.....	.....	.....	.....	.....	.....	.....	75.00	.....	.....	.....
84	Contributions	15	.....	.....	.....	.....	5.00	5.00	5.00	.....	.....	.....	.....	.....	.....
	Total	$13,960	100.00												

per cent on total sales, or $2,880, leaving a net gross profit, after deducting the desired net profit, of $14,670, which is the final amount that can be expended on the business and still leave the net profit. It is to be noted that I state that the net gross profit can be expended to operate the business "if absolutely necessary"; the fact that $14,670 on which to run the business is available does not make it mandatory that this amount be spent. Any part of it that is not spent becomes additional net profit. One should bear in mind, conversely, that if the expense budget is exceeded, only that small sum which is desired as net profit between operating the division at a profit or a loss remains. The division undeniably operates on a very narrow margin and it is only by knowing where every cent goes that one has a chance to retain a profit.

Direct Expenses and Their Allocation

To determine just how much of the $14,670 net gross profit must be used for expenses, thereby leaving only a fair net profit, or to determine whether or not the necessary expenses are to be in excess of this amount and thereby wipe out part or all of the amount we have determined upon as a fair profit, every item must be listed for which money must be expended and from which no income will be received, that is, those items which are a direct expense.

In Table 4 are listed a number of items that must be classified as direct-expense items. They may be grouped as one sees fit. The list of accounts or headings can be enlarged or condensed; for instance, Accounts 2 and 3, "Shop Tools" and "Repairs to Shop Tools," may be combined. One may decide also to separate the items into direct and indirect expense, classing under indirect such items as rent, power, light, heat, water and insurance. The cost of those items that are not affected by weather or other variable conditions is distributed through the year by the same monthly percentages as the total sales. If 10 per cent of the total sales is to be expected in April, we should expect to spend during that month 10 per cent of the total yearly allowance for miscellaneous supplies, shop tools and similar items, thus maintaining the ratio of expense to sales month by month, with the exception of Accounts 5, 65 and 81, which include power, light, heat, water, idle time and miscellaneous expense, such as vacations.

Explanation of Direct-Expense Accounts

Under Account 1, Miscellaneous Supplies, the sum of $240 is allowed in the budget for the year, or 1.72 per cent of the entire expense. This is based on a volume of $36,000 of business for the year. If the volume is to be twice as large, the expense item should be doubled, or if a station is doing only half that amount of business, the expense must be cut in half. All items listed are self-explanatory, I believe, with the exception of those in the following accounts:

5—*Power, Light, Heat and Water.*—These items will be heavier during the winter months, regardless of sales

6—*Errors and Allowances.*—This really is a service policy account, to which is charged an allowance made to a customer as a matter of policy

7—*Rent.*—This is the largest item to be considered. Referring to a previous statement that the service division can, under proper management, make a fair profit, I wish to make the qualifying statement that the service division must be suitably located for the purpose and housed in a building that can be operated efficiently and economically. Too costly a building or too expensive a location cannot be utilized successfully, and, if the management decrees that the service-station must occupy such a building or location, the service manager cannot hope to make a profit. He can, however, keep his other items of expense in proper proportion

10—*Service Vehicle Operation.*—This account includes expenses incurred in maintaining and operating a service car or "tow-wagon."

39—*Inspection.*—To this account is charged that part of the inspector's time that cannot justifiably be charged to car-owners for service jobs, such as time given to minor adjustments in periods of 5 to 10 min.

55—*General Labor.*—Under this heading is entered the cost of porter work and other necessary work of keeping the building clean and orderly

59—*Corective Labor.*—The cost of labor required to do over to an owner's satisfaction a job that is not properly performed the first time is charged to this account

65—*Idle Time.*—The expense for idle time varies with the season, being heaviest in those months when the least volume of business is done

81—*Miscellaneous Expense.*—Money paid to employes in their vacation periods or to extra employes while the regular employes are on vacation is entered under this head. The expense is distributed through June, July and August

Questions regarding other items and accounts will arise but the general procedure outlined will show how a budget is prepared and maintained.

It is not absolutely necessary for those who have been in business for several years and have records to go by to make an analysis by cars as described in the earlier part of this paper. They can determine the approximate increase in business per year on cars of different models and the approximate decrease on others, arriving at a very close figure. The main thing is to make a definite plan and have some operating basis upon which to work, as a result of which the year's work should be profitable, and then to follow the plan adopted.

Methods Used in Operating a Budget

It will be understood readily that to operate a budget successfully some one person must be responsible for all expenditures. If several persons are authorized to approve requisitions and allow various items of expense, no one will know what the others have approved and, as

HEAVY REPAIR - MARCH 1925

Date	Quantity	Size	Item	Price
3	4	3 x 3/8 in.	Tool Bits	$ 0.16 each
5	2	3 x 1/4 in	Tool Bits	0.08 each
8	1 Doz.	0.004 in	Feelers	0.15 each
11	1 Doz.	0.003 in.	Feelers	0.20 each
13	1/2 Gross	12 in.	Hack Saw Blades	0.50 each
13	10 Lb.	1/10 in.	Soft Iron Wire	0.065 per Lb.
15	1	6 x 1/2 x 3/4 in	Grinding Wheel - Grain 60 - Grade M	1.22 each
18	1	3/4 in.	C. S. Expansion Reamer - 129	2.64 each
22	1	7/8 in.	C. S. Expansion Reamer - 129	3.16 each
27	24 Bars	1/4 x 36 in.	Ferronite Steel - 19¢# - 16#	3.04 each

Fig. 1—Monthly Individual-Shop Expense-Record Card

Each Item of Direct Expense Requisitioned and Allowed Is Posted Daily on a File Card for the Shop Ordering It and When the Invoice Is Received the Unit Price of the Article Is Posted. Tne Cards Are Indexed by Months. These Records Show Whether an Item Is Being Bought Too Often and Keep the Service Manager Informed as to the Prices of the Various Articles

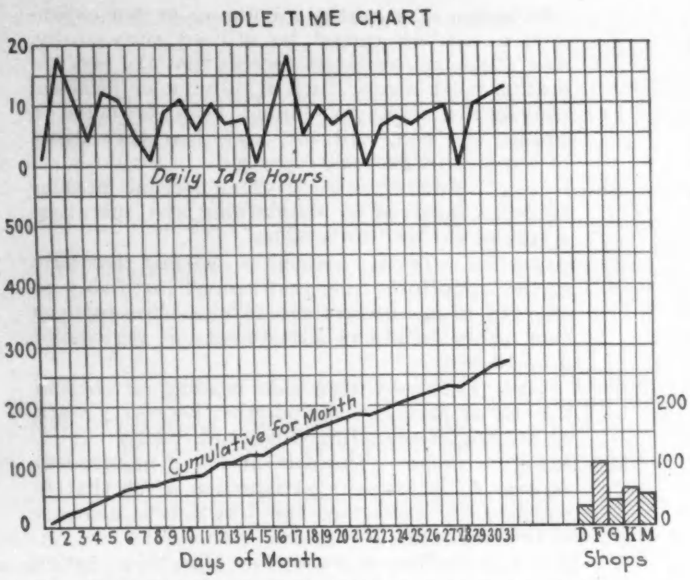


FIG. 2—DAILY AND CUMULATIVE CHART OF IDLE TIME
The Upper Curve Shows the Number of Idle Hours Each Day for the Month in the Service-Station by the Scale 0 to 20 on the Left. The Lower Curve Shows the Cumulative Idle Hours, Day by Day, Reading the Number of Hours by the Scale on the Left and the Days of the Month Across the Bottom of the Chart. In the Lower Right Corner the Total Idle Hours for Each of the Service Department Shops Is Indicated Cumulatively, Reading Vertically on the Scale at the Right. Each Day's Idle Time for Each Shop Is Blacked-In the Following Morning

a result, the end of the month may show a total of expense that is excessive. To avoid unusual or excessive expenditures in one's own business, I require that every item of expense shall be submitted to me for approval. Every requisition of expense, no matter how small, must have my approval, and, for my own information, I keep an individual card for each shop, as Minor Repair, Heavy Repair, Coach Shop and Paint Shop. When a requisition is received from the Heavy Repair shop and has been OK'd, it is posted on a 5 x 8-in. plain card, as shown in Fig. 1, and then sent to the purchasing division for execution. The cards are filed by months and when a new requisition comes down I check back to see when the last similar purchase was made. If I think that our purchases of the item desired are too frequent, the foreman is asked to give an explanation. The keeping of a complete record of the purchases by each shop and the knowledge by each foreman that if he buys too often he must explain, tend to keep the purchases at the proper level.

When an invoice is received, it is checked by the purchasing division and all expense items are sent to me. I, in turn, note on each card opposite each purchase the cost per item, which keeps me familiar with the prices of miscellaneous expense items and shop tools. If, during any particular month, I note that the demands from the shop for expense items are unusually heavy and that I have approved to within a danger limit of our budget allowance, additional requisitions are then cut down and smaller quantities are ordered, as the budget must be maintained at all times. Often we order only one each of articles that usually are purchased by the dozen. This does not increase costs, as we concentrate all buying with one or two companies and the usual discount prevails.

IDLE-TIME CONTROL-METHOD

Some idle time is experienced in every shop. It may be included under the title General Labor but it exists, nevertheless. We keep a monthly chart of idle time, as shown in Fig. 2, on which is posted daily the information given to my stenographer by the timekeeper, who merely enters on a small sheet of paper the total idle time for each shop. The posting does not require more than 5 min. daily. The lower curve, above the figures 1 to 31, indicates the days of the month and shows the cumulative total idle hours. The upper curve, opposite the scale 0 to 20, indicates the idle time each day. For example, if on the 2nd of the month we have 18 hr. idle time, it is plotted from the idle hours of the day before on the upper curve and is added to the idle time of the day before on the lower curve as cumulative for the first two days of the month. The chart indicates at a glance the total idle time up to any elapsed day during the month and also the idle hours for each individual day.

In the lower right corner the service division departments are designated by the letters *D*, *F*, *G*, *K* and *M*, representing such shops as the coach, paint, heavy repairs, minor repairs and electrical. In the columns above these letters is entered the amount of idle time in each shop each day in accordance with the scale at the right of the chart. These cross-patched blocks are cumulative and show at a glance which shop is having the most idle time and how much. Usually the chart sheet is made up of three charts covering a quarter year.

DAY-BY-DAY RECORD OF BUSINESS

It is important to know each day how business is progressing toward the goal for that month, instead of waiting until the end of the month to learn the facts. For this purpose a sheet, which is illustrated in Fig. 3,

BILLING FOR MONTH - MAY

BUDGET
$36,000.00

Date	1924	1925
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14	$16,000	$18,000
15	17,500	20,000
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		

FIG. 3—DAILY RECORD OF BUSINESS DONE
For Simplicity, All Amounts Are Omitted From This Example Except for the 14th and 15th of the Month. Cumulative Figures for Each Day from the First of the Month Are Typed in for 1924 and to Date for 1925. The Budget Expectation Is for a Volume of $36,000 for May, 1925. A Total of $18,000 Had Been Done up to the 14th, and $2,000 More Was Done the Following Day, Hence by the Middle of the Month the Business Exceeded the Budget Expectation and Also Showed a Gain Over the Previous Year

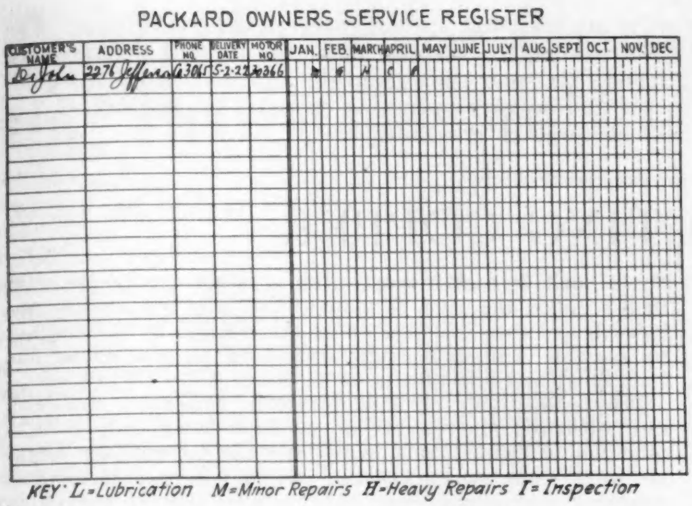


FIG. 4—OWNERS' SERVICE REGISTER
The Names, Street and Telephone Addresses, Car Engine Numbers and Dates of Delivery of Cars on Which Service Is Performed Are Entered on These Card Records, Followed by Symbols Indicating the Kind of Work Done. Each Monthly Column Is Divided into Four Weekly Columns and the Symbols Are Written in the Columns for the Week and Month in Which the Work Was Done. This Register Reveals Whether an Owner Is Bringing His Car in More Often than Should Be Necessary or Not Often Enough and Is Useful in Increasing Business in Slack Periods

shows the business done each day as it passes for the month. To use figures, assume that the expected business for May is $36,000 and that the record indicates that $18,000 has been billed prior to the 15th of the month. On the 15th an additional amount is billed that brings the total business for the first half of the month up to $20,000, as is posted at the right of Fig. 3, under the year 1925. From this record it is known each day whether or not the business is ahead of the budget or is falling behind. In the 1924 column of Fig. 3 has previously been typed the cumulative business for each day as done last year, so that it is easy to see by comparing the two columns whether we are gaining or losing over the preceding year and how much. It should be understood that in Fig. 3 all figures, except for the 14th and 15th of the month, have been omitted for simplicity.

USE AND VALUE OF OWNERS' SERVICE REGISTER

An owners' service register is also kept, which is reproduced in Fig. 4, on which are entered owners' names, addresses, telephone numbers, delivery dates and engine numbers. After each repair order is billed, the shop copy of the invoice is posted on the owners' register by a symbol designating the kind of work performed under that particular repair order. The register is divided into four weekly columns for each month and the symbols are many and varied. Thus, *AC* denotes accessory purchase; *M*, minor repair; *W*, washing, and *L*, lubrication.

This register is very useful, as it enables one to know at all times how often an owner's car comes into the station and what work is done on it. If the record indicates that the car is in too often, the service salesman who attends to the wants of that particular car-owner is asked to explain the reason or else the repair orders are withdrawn from the file and analyzed. The service register is also of assistance in maintaining the budget. We carefully scan each owner's record and if an owner is not bringing or sending his car in as often as we believe he should, we call him up, send a man to call on him or communicate with him by mail. We inquire first, of course, if the car is giving entire satisfaction. If so, we ask if the service we are rendering is satisfactory and then suggest that the car probably needs an inspection. This helps to increase business in a slack period, keeps us in touch with our customers and makes them feel that we have a real interest in the best functioning of their vehicles.

WHAT THE PRODUCTIVE-HOUR CHART TELLS

A record of the activity of the different shops is kept on a productive-hour chart, illustrated in Fig. 5, which reveals the general tendency of our business. This record goes back to September, 1922, and is continuous to December, 1924. The several curves in solid, broken and dotted lines indicate by the scale on the left the number of productive hours of work on cars, on trucks and on coaches and the number of repair orders written, and, by the scale on the right, the total number of shop productive-hours as indicated by the curve at the top of the chart. By comparing the record of work in any month of the current year on any class of vehicle with the record for the corresponding month last year or two years ago, we know whether the work is increasing or decreasing. To illustrate, the production of Packard trucks was discontinued about 3 years ago, but the trucks previously built will, of course, be in operation for several more years. It will be noted that the truck productive-hours have been excellent but that the graph line shows a fairly steady decline of truck service work since January, 1924. This chart, like the others, aids us to know at all times exactly how our business is operating and what we may expect in the future.

I wish to forestall any criticism that might be made that the preparation and keeping of these records require too much detail work and time. Except for the brief time required for me to O K requisitions and post the work cards to the owners' vehicle register, one girl in less than 1 hr. per day keeps all charts and records that require posting daily uptodate. On the first of the month, when the accounting department submits its re-

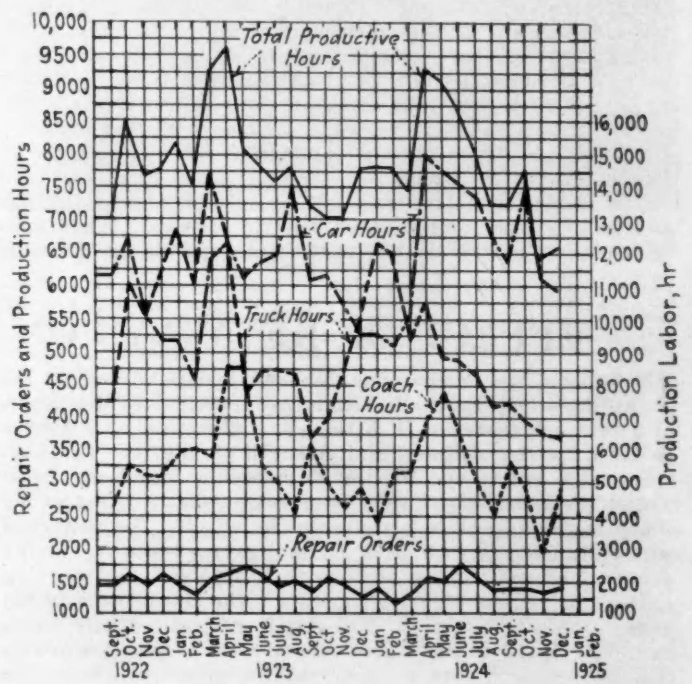


FIG. 5—CHART OF PRODUCTIVE HOURS
The Upper Solid-Line Curve Shows the Number of Hours of Productive Labor for the Service-Station by Months for 2½ Years, As Read on the Scale at the Right. The Lower Solid Line Shows the Number of Repair Orders by Months, Read on the Scale at the Left. The Intermediate Broken and Dotted Lines Show the Productive Hours Devoted to Car, Truck and Coach Work, Also Read by the Scale at the Left. This Chart Reveals the Tendency of the Business According to Classes of Work

port for the preceding month, she devotes about half a day to checking the comparative figures with those our budget calls for to show the result that was actually accomplished in the month. She also keeps several other daily records pertaining to different phases of the service business that are not referred to in this paper. The time needed for keeping all of the records that give the service manager such complete information for his guidance and decisions need not exceed 2 hr. per day, if it is all centered in one individual.

SUPER-CONDUCTING COPPER

PROF. A. E. KENNELLY, in a Retrospect in Research, tells how Lord Kelvin in 1857 found that copper wire used in cable manufacture differed much in conductivity and urged that Transatlantic cables be made of high-conductivity copper, chemically pure metal that was capable of transmitting current with much less loss than occurred in the usual, more or less impure, copper. This was one of the early applications of research to finding better electrical conductors.

From that day to this, pure copper has been used almost exclusively for electrical transmission. The only known material with higher conductivity than pure copper is silver, a metal too costly for use in line wires. But in spite of this settled practice, interesting questions remained. Why is silver more conductive than copper? Why is copper, next to silver, more conductive than all other metals? Is its conductivity absolutely a fixed thing, or is it susceptible of increase by special treatment?

A small increase in the conductivity of commercial copper would have great value. An increase of even 10 per cent would release for other fields an enormous tonnage of copper now used for transmitting power. The economic radius of all existing transmission systems would be increased 10 per cent, increasing by 21 per cent the area served; or the underground cable subways of cities, so many of which are taxed to capacity with their loads of today, could without enlargement carry additional loads of 10 per cent.

Producing Single Large Crystals

When Dr. W. P. Davey, of the research laboratory of the General Electric Co., found by calculations, based on the arrangement of the copper atoms which the X-rays revealed, that copper composed of a single crystal should have a conductivity 14 per cent greater than ordinary copper, greater than that of silver, possibilities of great scientific interest were disclosed. To check his calculations, Dr. Davey proceeded to devise apparatus for producing large single crystals of copper.

The single crystals were made by very gradually heating and cooling pure copper in an electric furnace. When molten metal is quickly cooled, very small crystals are formed; if the melt is cooled slowly, the crystals are larger. Dr. Davey cooled the melt so slowly that only one crystal was formed, and that included all of the metal. By this method he was able to produce single crystals ¾ in. in diameter and 6 in. long, and one that is 14 in. long.

The conductivity of these crystals was then measured, and, although the quantities involved were only 0.00036 volts and 0.000018 ohms, measurements by different methods were made which checked within 0.25 per cent. The measured conductivity was 113 per cent that of pure polycrystalline copper, within 1 per cent of the calculated value.

Structure of the Copper Crystals

In a crystal, the atoms are built up in regular fashion. The crystals of copper, for example, are made up of very tiny cubes, with atoms of copper at the corners and centers of the faces of each unit. The larger crystals grow in such a direction that the atoms are arranged in columns along the length of the crystal. It is this regular arrangement of the atoms, which, it is believed, gives to the single crystals their superior conductivity when compared with ordinarily polycrystalline copper, in which the crystals are small and the arrangement of these small crystals very chaotic.

There is reason to believe that the conductivity of copper crystals along another axis from that measured may be even 60 per cent greater than the value of pure copper, but the growth of single crystals along this other axis has not yet been brought under control. Unfortunately, no immediate prospect of utilizing commercially this newly discovered high conductivity exists, for the single crystals are very delicate and difficult to manufacture.

One of the first facts discovered about single-crystal copper was that the specimens could be bent double with one finger, but that strength was required to straighten them afterwards. A crystal of the size of a lead pencil, if given a jerking motion, bends like a stick of soft wax. Having been once bent, however, it acquires the properties of ordinary copper, for the bending has transformed the large crystal into a mass of smaller ones.—Research Narrative No. 105 of the United Engineering Society.

EFFECT OF KEYWAYS ON THE STRENGTH OF SHAFTS

IN Reports and Memoranda No. 864 just published by the Aeronautical Research Committee particulars are given of a research made by H. I. Gough on the effect on keyways in reducing the stiffness and strength of shafts. The keyways were cut to the British Engineering Standards Association's standards and were purposely made with extremely sharp corners so as to accentuate the effect. The materials employed were Armco iron, chosen as representing highly ductile material, and a steel with a 0.65-per cent carbon-content, as typical of harder metals. The shafts were tested under alternating torsion. The elastic strength of both materials was found to be in good accord with theory, the reduction as compared with a plain shaft being 23 per cent. The ultimate strength of the Armco iron under alternating torsion was, however, very much higher than theory would indicate, since it was only 12 per cent less than that of a plain shaft of the same material. The ultimate strength of the hard steel shaft was, however, in very fair accord with theory, the reduction in strength being 21 per cent as compared with a theoretical value of 24 per cent. These tests emphasize the need for caution in applying observations made with one material for fixing the stresses that can safely be allowed on another and show once again that, though the mathematical theory of elasticity provides us with a means of calculating stresses, these stresses may afford but a poor criterion of the actual strength of a structure. The harder the material, the greater is the reliance that can be placed on the theory, and the more nearly does the elastic strength agree with the ultimate—*Engineering* (London).

A Machine for Comparing the Lubricating Properties of Oils at High Pressures[1]

By C. F. Marvin, Jr.[2]

Illustrated with Photograph and Charts

ABSTRACT

The usual laboratory tests of lubricants do not indicate to what degree a given oil may possess the important property of "oiliness," a property, apparently independent of viscosity, upon which the ability of an oil to maintain lubrication between two surfaces under high pressure seems partly to depend and by which some sort of extremely tenacious and adherent thin layer of oil is held on one of or both the rubbing surfaces so that metal-to-metal contact is in part prevented. Oiliness is of special importance in metal-cutting operations and in some machine parts, such as gear teeth or cams under heavy loads, in which the pressures between the surfaces are far in excess of those permitted in plain bearings.

With a view to investigating the behavior of various lubricants, cutting compounds and bearing materials under high bearing-pressures, a special machine has been designed, of which a description is given and data are presented. These, however, are said to be rather illustrative of the results obtainable than indicative of the exact characteristics of the materials used. Tests were made to determine the points at which noticeable abrasion takes place, the adaptability of different cutting-oils to different metals, the approximate magnitude of the pressures involved, the effects of the speed of the rubbing surface, of temperature, and of varying the amount of lubricant on the coefficient of friction and the comparative friction-reducing properties of vegetable, animal and mineral oils.

Among the conclusions reached are that (*a*) with smooth and accurate grooves and balls, consistent and reproducible results can be obtained; (*b*) decided differences in the friction-reducing properties of different oils occur below the point of noticeable abrasion; (*c*) above this point the friction varies widely as the rubbing surfaces wear and no consistent values of the coefficient of friction have been obtained; and (*d*) the character of the abrasion seems to be related to the nature of the lubricant.

This paper constitutes a preliminary report on a device designed to show the behavior of various lubricants, cutting compounds and bearing materials under high bearing-pressures. The data presented are illustrative of the results obtainable with the device rather than indicative of the exact characteristics of the materials used, although some rather striking differences have been observed. It is believed, however, that the results obtained are of sufficient value to be presented at this time without waiting until more comprehensive data can be secured.

The ability of an oil to maintain lubrication between two surfaces under high pressure is dependent partly on some property of the oil that apparently is independent of viscosity and has been termed "oiliness." Probably the simplest and most general conception of oiliness is that, by some means not well understood, some sort of extremely tenacious and adherent thin layer of oil is held on one or both of the rubbing surfaces, so that direct metal-to-metal contact is in part prevented.

In metal-cutting operations, and in some machine parts, such as gear-teeth or cams under heavy loads, the pressures between the surfaces in contact are far in excess of those permitted in plain bearings, and the conditions do not allow the establishment of a definite oil-film, as is the case in journal lubrication. It is in such cases that oiliness is of special importance, although there is reason to believe that it may be a factor in the behavior of lubricants in all classes of service.

The usual laboratory tests of lubricants do not indicate to what degree a given oil may possess this important property. The need of a laboratory method of comparing the behavior of different oils at high pressures led to the design of a device, the essential parts of which are shown in Fig. 1.

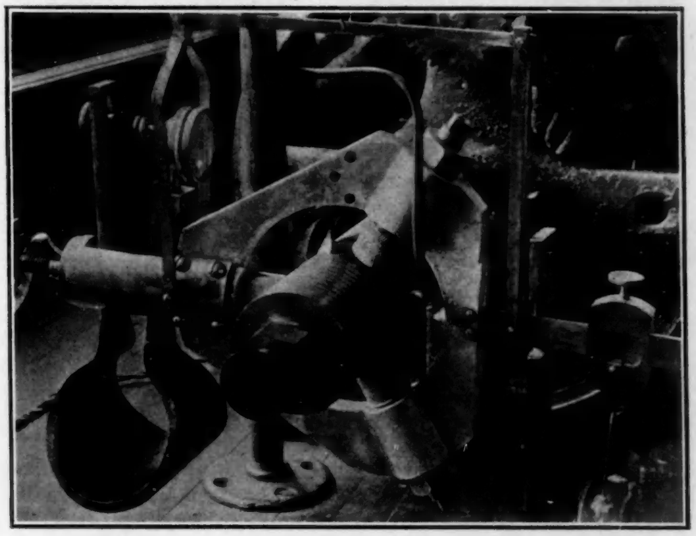


Fig. 1—Machine for Comparing the Behavior of Oils Under High Pressure

A Triangular Frame Carries Three Symmetrically Placed ½-In. Balls of Steel or Other Material, Mounted So as To Slide Without Turning in One of a Number of Similar Grooves Cut in a Cylinder of Any Desired Material. The Motion of the Frame Is Restricted and Its Tendency To Rotate With the Cylinder Is Measured

Apparatus

A triangular frame carries three symmetrically placed ½-in. balls of steel or other material, mounted so as to slide without turning in one of a number of similar grooves cut in a cylinder of any desired material. The cylinder is rotated by an adjustable-speed motor. The motion of the frame is restricted and its tendency to rotate with the cylinder is measured. Pressure is applied to the bearing-surfaces by a spring. Spring deflections are shown at all times on a dial-indicator, the reading of which is sufficiently accurate measure of the load applied to the balls. Means are provided for water-cooling the spindle, feeding a small quantity of oil onto the groove and measuring the temperature of the lubricant.

[1] Published by permission of the Director of the Bureau of Standards.

[2] Assistant mechanical engineer, Bureau of Standards, City of Washington.

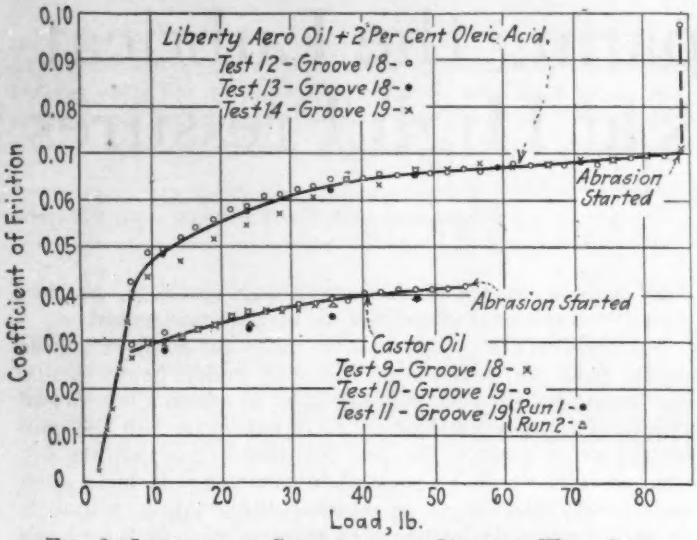


FIG. 2—INCREASE OF COEFFICIENT OF FRICTION WITH LOAD
The Difference between the Friction-Reducing Properties of Castor Oil and of a Mineral Oil of Approximately the Same Viscosity to Which 2 Per Cent of Oleic Acid Had Been Added Is Very Marked

The smoothness and fit of the rubbing surfaces have a decided influence on the results obtained. When the small dimensions of the contact-areas are considered, it is evident that a slight roughness or unevenness of either the balls or the groove will have an effect on the magnitude and distribution of pressure and will tend to cause abrasion of the high spots. Since abrasion usually spoils a surface for further use, it is necessary, in order to obtain consistent and reproducible results, to use balls and grooves accurately ground or burnished, so that any part of any ball will fit any groove over the same length of arc of contact. New and similar surfaces can be obtained for successive tests by turning the balls slightly in their sockets and using a new groove. The surfaces of the balls and grooves should be as uniformly smooth as possible. Frictional force is the quantity measured with this appliance, but other factors, such as the mechanical behavior of the metals, may be of equal importance in interpreting the results obtained.

ABRASION

Although some wear may have taken place under all the conditions of operation employed, wear is hardly

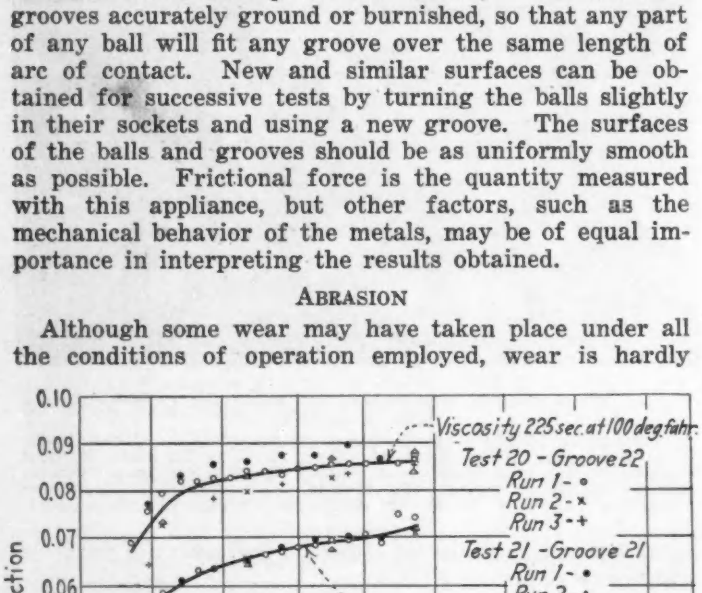


FIG. 3—INCREASE OF COEFFICIENT OF FRICTION WITH LOAD
The Heavier of Two Fractions from a Petroleum Lubricating Oil Distilled under Vacuum, Gave a Consistently Lower Coefficient of Friction than the Lighter One

noticeable at low pressures and causes little change in the coefficient of friction. If the load is gradually increased, however, a more or less definite point will finally be reached at which very noticeable abrasion will take place. The arrival at this point is usually announced by an increase of, and a wide variation, in the frictional force and is accompanied by a marked wearing-away of the balls or the groove.

BEARING MATERIALS

The machine is designed to make possible the use of a wide variety of metals. This feature is of special importance in the testing of cutting oils that must be used with many different metals under conditions in which the nature of the metal is as much a factor as is the kind of lubricant.

Tests were first run with a brass spindle and steel balls such as are used in ball-bearings. At relatively low pressures these materials run together smoothly with no appreciable wear, and the results are consistent and reproducible. Abrasion of the brass is always imminent, however, and once started will continue even under re-

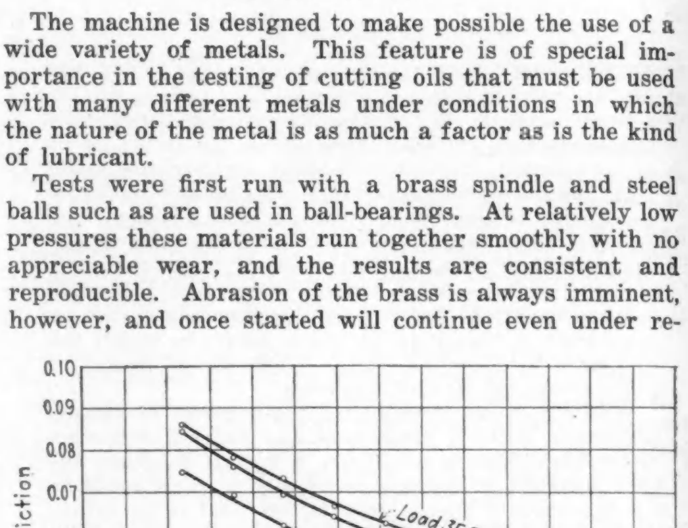


FIG. 4—DECREASE OF COEFFICIENT OF FRICTION WITH INCREASE OF RUBBING VELOCITY
Results with the Same Oil at Three Speeds Are Shown

duced pressures, producing chatter-marks in the groove and decided vibration of the apparatus. The steel balls suffer very little wear but often show a deposit of brass after a test in which rapid abrasion has occurred. In many cases the brass is badly abraded, though the lubricant is still effective in reducing friction.

Later tests were made with a steel spindle and agate balls in an attempt to get bearing materials sufficiently hard to withstand pressures high enough to squeeze out the oil-film and break-down the lubrication completely. The agate balls, however, failed before the lubrication, as was evidenced by the fact that at pressures high enough to cause wear and chipping of the agate balls, the coefficients of friction in the presence of oil were only from one-quarter to one-half as high as were the coefficients of unlubricated friction.

The coefficients of friction were somewhat higher for agate and steel than for steel and brass, but the harder materials did not show the rapid variations in friction that accompanied the abrasion of the brass spindle. The data plotted in Figs. 2, 3 and 4 were obtained with the brass spindle and steel balls. Fig. 5 was obtained with the steel and agate combination. These figures show the effect of various operating conditions on the coefficient of friction.

Pressure, Velocity and Temperature Effects

Only the total load is measured on the machine. An attempt was made to determine the approximate magnitude of the pressures involved by measuring the areas of the abraded portions of the balls after test. The highest pressure so estimated was 65,000 lb. per sq. in. The behavior of the frictional coefficient with change of load varied somewhat with different lubricants but, in general, showed an increase with increase of load, the curves in Figs. 2 and 3 being typical.

The effect of the speed of the rubbing surface on the coefficient of friction with the same oil at three loads is shown in Fig. 4. The frictional force decreases as the velocity increases with all the lubricants tested.

Temperature is measured by a thermocouple placed close to the groove in one of the oil-scrapers. The effect of temperature on the coefficient of friction is probably partly due to the change in the viscosity of the lubricant. A rise in the coefficient of friction with an increase of temperature, as illustrated in Fig. 5, was general for all the lubricants tested.

Amount and Character of Lubricant

A very thin film of oil is effective in reducing the friction, a small quantity fed into the groove by scrapers in front of each ball providing ample lubrication. Oil in excess of this quantity has no effect on the friction.

Fig. 2 shows the very marked difference between the friction-reducing properties of castor oil and of a mineral oil of approximately the same viscosity to which 2 per cent of oleic acid has been added. Abrasion with castor oil began at a lower pressure than with mineral oil. How much this is due to the properties of the oil and how much to the condition of the surfaces in contact, is uncertain. Abrasion begins at different pressures in different tests of the same oil, the pressure at which it begins apparently depending very much on the condition of the surfaces in contact.

The type of abrasion varies somewhat with different oils. With the brass and steel unlubricated, the abrasion is excessive and results in a roughening and scratching of the groove and a heavy deposit of brass on the steel balls. Somewhat similar effects were observed with several mineral oils. Abrasion, in the case of castor oil, is never accompanied by a deposit of brass on the balls and results in a polishing of the groove. With lard oil, abrasion begins at a very low pressure, results in a very rapid wearing-away of the brass and leaves a thin even deposit of brass on the balls. The groove, however, retains a smooth and polished surface in the presence of lard oil. It is possible that the same properties which make lard oil a good cutting-lubricant are responsible for its action in this machine.

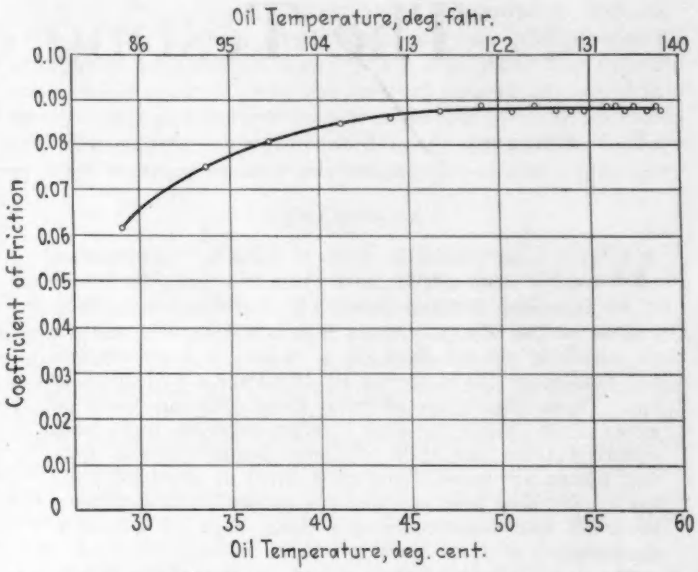


Fig. 5—Increase of Coefficient of Friction with Temperature
Rise of the Coefficient of Friction Was General for All the Lubricants Tested, Probably Due to a Change in the Viscosity of the Lubricant

The runs plotted in Fig. 3 were made with two different fractions, distilled under vacuum, from a petroleum lubricating oil. The heavier fraction, with a viscosity of 600 Saybolt sec., at 100 deg. fahr., gave a consistently lower coefficient of friction than the lighter fraction with a viscosity of 225 Saybolt sec. at 100 deg. fahr.

Conclusions

The tests made so far with this machine have been of the nature of preliminary tests to determine the possibilities of the machine as an "oiliness" and cutting-lubricant tester. The curves show that, with smooth and accurate grooves and balls, consistent and reproducible results can be obtained. The results show decided differences in the friction-reducing properties of different oils below the point of noticeable abrasion. Beyond this point, the friction varies widely as the rubbing surfaces wear, and no consistent values of the coefficient have been obtained. The character of the abrasion, however, is of interest as it seems to be related to the nature of the lubricant. Although the area of contact cannot be definitely determined, it is of little consequence when only comparative tests are desired.

The Testing of Sheet Steel

By E. F. Collins[1]

Detroit Section Paper

ABSTRACT

WILL sheet steel that is to be used in the manufacture of automobile parts form the parts for which it is intended without breaking, buckling or pulling coarse at the sharp corners is a question, the answer to which is sought through a series of tests applied to samples of the material by the Packard Motor Car Co. Three sheets are selected from different parts of every 1000 sheets received. After sections have been removed from the ends of these sample sheets, four test pieces are taken from each sheet at specified locations and these last samples are subjected to Erichsen, Rockwell and tensile-strength tests, each of which is discussed.

The general conclusions reached are that if the Erichsen values are uniformly more than 10.3 mm., if the Rockwell hardness *B*-scale is between 25 and 40, the elastic-limit-tensile-strength ratio not more than 60 per cent, the elongation about 30 per cent, the microstructure of normal and uniform grain-size, the grain boundaries are sharply defined and the steel is clean, no trouble in forming deep-drawn stampings may be anticipated.

THE testing of sheet steel to be used in stampings for the manufacture of automobile parts, especially those requiring a deep draw for their formation, can be divided into two general classes according to the answers to the following questions: (*a*) Will the steel form the part for which it is intended without breaking, buckling, or pulling coarse at the sharp bends? and (*b*) Will the surface finish of the stamping be suitable for the purpose intended without requiring that an additional amount of labor shall be put on it? The discussion that follows will be confined to bringing out points that may be helpful in answering the first question. With the exception of stretcher strain, on which few actual data are available, the answer to the second question is largely dependent on the surface inspection of the sheet.

In testing any material, the first and most important point to consider is the representativeness of the sample. If we are to obtain a true picture of the drawing qualities of a shipment of sheet steel, the samples from which that shipment is to be judged must be representative of the shipment, that is, the test specimens taken from each sheet tested must show the drawing qualities of all parts of the sheet. Assuming, therefore, that sheets have been selected from different parts of the lot to be tested and that specimens from these sheets represent the whole sheet, a true estimate of the drawing qualities of the shipment can be obtained.

Method of Taking Samples

Because of the method used in the manufacture of sheet steel, the task of selecting sheets that are an average of the lot is not easy, but, on the other hand, is not impossible. We have found in our work that, if three sheets are taken from different parts of each 1000 sheets received, and if the test results check, we can feel fairly sure that we have obtained an average sample. If one or more of these sheets give erratic results, other sheets are checked until we are sure which figures are correct. Test-specimens are cut from each sheet in the following manner. First, sections 3 in. wide are cut from each end of the sheet for the full width and are thrown away; then two sections 2¾ in. wide and of the full width of the sheet are cut off and marked Nos. 1 and 3. Next, a section 2¾ in. wide and of the full width of the sheet is cut off from a point near the center of the sheet and is marked No. 2. These specimens are used for Erichsen and Rockwell tests, as will be explained later. Finally, a 2-in. strip is taken parallel with the direction of rolling at a distance of about one-third the width of the sheet from the outside edge and as near to strip No. 2 as possible. This is marked No. 4 and is used for the tensile-strength tests.

Erichsen Tests

Erichsen tests are made about every 6 in. across the three 2¾-in. strips and Rockwell hardness *B*-scale readings are taken between each pair of Erichsen impressions. The tensile-strength test-bars used have a 1-in. test-section and measure 2 in. between the punch-marks.

In the Erichsen test, the metal is held between binder-rings in a manner similar to that in which the blank is held by the pressure-rings of a forming die, and the round-nosed plunger acts similarly to the punch of a forming die, so that a cup is formed; the depth to which this cup can be drawn before fracture occurs is recorded in millimeters. This value is representative of the metal affected and, as readings are taken across both ends and the center of the sheet, the assembled results give a good picture of the drawing quality of the entire sheet. The Rockwell hardness readings taken between the Erichsen impressions serve as a check on the Erichsen values obtained.

Result of Insufficient Annealing

One of the common and most serious conditions shown by this series of tests is the hard or insufficiently annealed areas in the centers of the sheets. These are often the cause of breakage, buckling and coarse surface at the sharp bends. When photomicrographs of these areas are made, it is often found that a strained condition has been set up in the rolling that had not been eliminated by the annealing. Some sheets that give good Erichsen and Rockwell values will show remnants of this strained condition. It is interesting to note that, if the grain boundaries are sharply defined, the sheets will form in spite of their strained structure.

Our laboratory-test record-cards are marked to show the outlines of several sheets, and the Erichsen, Rockwell and tensile-strength results are marked within these outlines in the same relative positions as are the areas of the sheets tested, so that after the results have been marked on the cards a complete picture of the drawing quality of the sheets can be seen at a glance. Any low or high test-areas in any of the sheets are easily noticeable. If the centers or ends give low Erichsen or high Rockwell values, trouble in forming may be anticipated. Just how serious these troubles will be depends to a large extent on the nature of the stamping to be made.

[1] Metallurgical department, Packard Motor Car Co., Detroit.

In making tensile-strength tests, the yield-point is determined by reading the beam load that produces the first permanent set. Lines are scribed on the test-piece exactly 2 in. apart. When this distance becomes greater than 2 in. and remains so after the load has been released, the yield-point has been passed. This point is checked by the drop of the beam, the breaking load noted, and the amount of elongation measured.

Ratio of Yield-Point to Ultimate Tensile-Strength

An interesting, and we think an important, quality-factor has been developed which helps the judging of the drawing quality of sheet steel, namely, the ratio of the yield-point to the ultimate tensile-strength. For instance, if the yield-point is 20,000 lb. per sq. in. and the ultimate tensile-strength 40,000 lb. per sq. in., this ratio would be 50 per cent. The width of this zone is important, because no permanent set or elongation takes place until after the yield-point has been passed and, obviously, no work can be accomplished after the breaking-point has been reached. The greater the distance is, therefore, between the yield-point and the breaking-point, the greater will be the ability of the steel to have useful work performed on it.

Take two stampings, for example, one of which begins to form after a load of 20,000 lb. per sq. in. has been applied to it and breaks when 40,000 lb. per sq. in. has been applied, and a second that does not begin to form until 30,000 lb. per sq. in. has been applied, yet breaks at the same load of 40,000 lb. per sq. in. In the first instance, 20,000 lb. per sq. in. has done useful work, while, in the second case, only 10,000 lb. per sq. in. has been effective.

The microstructure of sheet steel is a good check on its physical properties. It is especially useful in explaining low test-results or why a stamping was defective. Inclusions; impurities, such as phosphorus at the grain boundaries, large grain-size near the outside with small grain-size at the center, caused by annealing ferrite that has been critically strained by cold working, and the insufficiently annealed condition of the centers or ends of some sheets, are among the causes of failure.

Conclusions

To sum up, it might be said in a general way that, if Erichsen values are uniformly more than 10.3 mm., if the Rockwell hardness *B*-scale is between 25 and 40, the elastic-limit-tensile-strength ratio is not more than 60 per cent, the elongation approximates 30 per cent, the microstructure is of normal and uniform grain-size, the grain boundaries are sharply defined and the steel is clean, no trouble in forming deep-drawn stampings may be anticipated. The results given in Table 1 will bear out these statements. This table presents the average test-results obtained in the last 6 months on more than 300 shipments, all of which worked well in the shop.

TABLE 1—AVERAGE TEST RESULTS OF SHEET STEEL

Kind of Test	Average Reading
Erichsen, mm.	10.46
Rockwell *B*-scale	38.20
Yield-Point, lb. per sq. in.	23,900
Ultimate Tensile-Strength, lb. per sq. in.	41,800
Elongation, in 2 In., per cent	30.23
Elastic-Limit-Tensile-Strength Ratio	56.73

Shipments or parts of shipments, in which the Erichsen results were not uniformly more than 10.3 mm. and the elastic-limit-tensile-strength ratio was not greater than 60 per cent invariably gave trouble in forming.

AGRICULTURAL EXPANSION

OUR rate of population growth has been falling. The native-born birth-rate has been declining since 1810, and the birth-rate among foreign-born peoples falls rapidly in the second generation. The present immigration law is holding back the fecund foreign groups. The need for more food producers is growing less, relatively speaking. The invention of machinery and the improvement in agricultural technique have increased agricultural production per man and per acre. Sir Daniel Hall says that in a country that is self-sustaining only 10 per cent of the people are needed to feed the nation.

Forecasts of population indicate that by 1950 the population of the United States will be about 150,000,000 people. This is only 25 years hence, but a long enough period to affect the present and next generation of farmers. The Department of Agriculture has estimated that with only a moderate change in our consumption habits and a slight increase in the productivity of our soils this population increase can be supported by an addition of only 40,000,000 acres of crop land and improved pasture. During the war we added 45,000,000 acres to our crop land. Some 400,000,000 acres of potential arable land—that is, ranch land, and irrigable, drainable, forest and cut-over land—are available to choose from. The conclusion of the Department of Agriculture is

> In view of these possibilities it seems hardly necessary to reclaim a large area by irrigation or drainage for the expansion of agriculture during the next few decades, and certainly there would be no justification in undertaking such reclamation except in the case of projects where the economy of reclamation could be demonstrated unequivocably.

Our past land policies have neglected entirely the relation between population and the supply of arable land. Settlement was pushed far beyond the food needs of the Nation. We swamped the East and Europe with food at bargain-counter prices at the expense of the farmers. Marketing reform and cooperative marketing are hailed as panaceas, but these have their limitations. Even the "eat-more" campaigns cannot expand the internal capacity of our consumers. If you eat more wheat, you must eat fewer potatoes; if you buy of one farmer, you bring distress to another.

The most successful farmers of Europe are without doubt the Danes, who practise a highly commercial agriculture by producing for the foreign market and an urban market within their own country. Nowhere in Europe will one find the culture, comforts and conveniences among the rural people such as the Danish farmers enjoy.

In manufacturing we are ever striving for cheaper and cheaper production, and the manufacturer derives a profit from large sales. The manufacturer scraps poor material and instruments and is always looking for better material, instruments and processes. It is not so easy to scrap poor land, but that has to be done and on a large scale. Not half of the land of the Country is good farming land; to farm it means poverty for many and often a disastrous glut in the market.—From a paper by R. T. Ely and G. S. Wehrwein, presented before American Society of Agricultural Engineers.

A Fundamental Demonstration of Cooling by Steam

By H. L. Horning[1]

Illustrated with Drawing

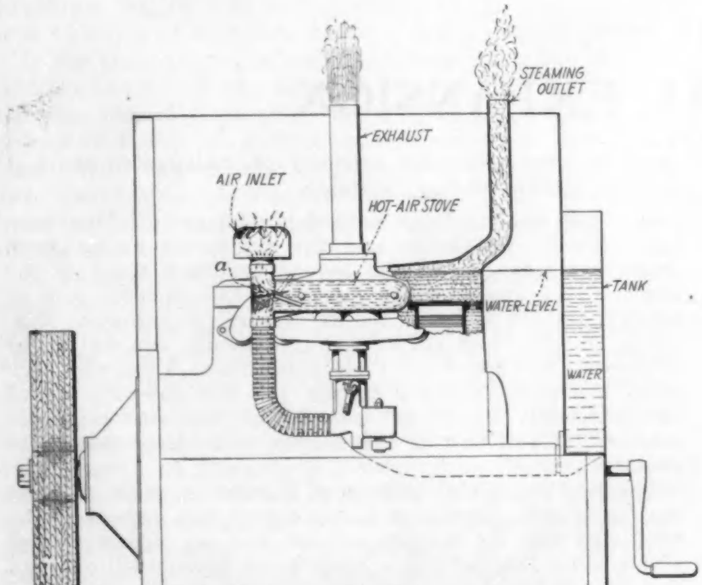
ABSTRACT

With the "set-up" shown in the accompanying illustration, a demonstration devoid of superfluous details was made of an engine operating while cooled by a simple steam cooling-system. Details of the set-up and of the procedure are stated. The conventional water-cooled engine used, of 3¼-in. bore and 4½-in. stroke, had no special provision for steam-cooling incorporated in its design. It ran smoothly and without detonation, even when part of the head was uncovered by water; it stopped promptly where the water level was maintained, showing that no preignition occurred. Throughout the test, the engine functioned properly, it idled well and the cooling was satisfactory.

The object of the experiment[2] described herein was to show an engine running under a simple fundamental steam cooling-system, devoid of distracting engineering details that are necessary for every-day running and are subject to patent problems. No man can patent a principle. He can patent a new means to attain certain results by use of the principle.

[1] M.S.A.E.—President and general manager, Waukesha Motor Co., Waukesha, Wis.

[2] Made at the Semi-Annual Meeting of the Society, White Sulphur Springs, W. Va., June 17, 1925.



Drawing Showing General Arrangement of the Steam Cooling-System

In This System the Accessories Ordinarily Required for Cooling Are Discarded, and the Engine Is Kept Cool by the Continued Evaporation of Water. Consequently No Pump Is Required To Circulate Water, a Fan Is Not Needed To Increase the Draft To Facilitate Cooling and the Radiator Is Dispensed With. In Starting and When the Engine Is Idling the Valve *a* Is Closed as Shown by the Full Lines, Causing the Air from the Air Inlet To Pass through the Hot-Air Stove, as Indicated by the Arrows, and Thence to the Carbureter at a High Temperature. Under Full Load the Valve Automatically Opens as Shown by the Dot and Dash Lines, Permitting Cold Air To Enter the Carbureter. At Intermediate Loads the Valve Adjusts Its Position To Vary the Temperature of the Incoming Air To Suit the Engine's Requirements

In this "set-up," which is shown in the accompanying drawing, the accessories ordinarily required for cooling are discarded. No pump is required to circulate water, no fan is needed to increase the draft to facilitate cooling, and the radiator is dispensed with. The engine is kept cool through continued evaporation of water.

A tank is provided with a top, the level of which is above the cylinder-head; also a connection with the cylinders, at the bottom, so that water poured into the tank may seek a natural level within the cylinder-heads. The loss of water due to steaming is made up by water added to maintain the proper level in the tank.

The level in the tank is substantially the same as that in the cylinders. Water flows slowly from the tank to the bottom of the cylinder water-jacket, at the side opposite the valves. Practically no mechanical disturbance of the water in the jacket, except the flow to the steaming surfaces, occurs.

The engine, of conventional water-cooled design, has a 3¼-in. bore and a 4½-in. stroke. No special provision for steam-cooling was made in the engine design. There are no so-called steam-pockets or trapped-air spaces, to prevent vertical or side movement of steam out of the water-jackets into the cylinder-head. The engine was run at 1800 r.p.m., at which speed it developed 27 hp., which was absorbed by a "stick" attached to the flywheel.

The engine was started and, there being no water circulation, there was a rapid heating of the water in the cylinders. When steaming, at any load or speed, there was an orderly emission of steam, without belching or surging, the volume of steam generated apparently becoming proportional almost instantaneously to the changed load or speed. This was particularly noticeable when the demands were increased. The engine ran smoothly, and without detonation, even when part of the head was uncovered by water. The engine stopped promptly, when the water level was maintained; showing that there was no preignition.

When the steam outlet is blocked, the steam pressure naturally increases and the water-level in the tank rises and that in the engine becomes lower. Maintaining this condition causes the tank water to be discharged. This corresponds to what happens in "water-cooling" when that system becomes disorganized by steam pockets; that is, when there is a conflict between steam-cooling and water-cooling. A dipper of water, when held over the steaming outlet, heats up promptly while condensing the steam. This illustrates the great heat-content of vapor.

In this engine three outstanding recommendations crystallized in the cooperative fuel-research sponsored by the automotive and the oil industries were incorporated, as follows:

(1) Uniformly high jacket-temperature
(2) Hot crankcase-oil
(3) Hot intake-gases at low load or idling

These temperatures were in the low crankcase-oil

dilution-range. To determine the friction, the deceleration was measured by noting the time required for the engine to come to a stop from a speed of 1800 r.p.m. With the water at 150 deg. fahr., the time required to stop was 20 per cent less than that required for stopping when the water was 212 deg. fahr. and steam was emitted freely. This demonstrates the low friction-loss with steam-cooling.

The heat-loss to the cylinder walls can be determined by maintaining the water-level in the cylinders, supplying water from a graduated pipette replacing the water-tank. Knowing the amount of gasoline consumed, the power developed and the water evaporated by the water-jackets, we can calculate the heat-balance.

The engine was run at times with the water-level so low that the valve-seats were "cooled" by wet steam only. Apparently no ill effect in running resulted from this. The engine functioned properly and idled well throughout the entire test, and the cooling was satisfactory in every respect.

Many engineers have associated steam in water-cooled systems, under high loads, with distress in the engine, detonation and preignition and have felt that there are reasons why a cylinder or hot surface will not dissipate its heat through steaming. This demonstration had no object except to show that this can be done and probably is done in some form or to some extent in all engines. It is hoped that the proof was clear.

Shock-Absorber and Snubber-Device Developments[1]

By W. B. Groves[2]

IN the shock-absorber field, the most recent developments have shown a tendency toward instruments that check only the recoil of the car spring. This is due primarily to the fact that more attention has been given to the designing of car springs than ever before. The flexible springs now being used in conjunction with balloon tires make it unnecessary to provide an auxiliary spring device to help soften the riding quality of an automobile spring when compressing.

Several new one-way operating devices have come into the market in the last 2 or 3 years. These vary in principle and in method of braking the car-spring recoil, but all are designed to accomplish the one purpose of controlling disagreeable spring recoil that necessarily follows when a car equipped with balloon tires and flexible springs passes over abnormal inequalities in the road.

A few of the later shock-absorbers that have come into the market have overcome the fault of some of the older devices in that they do not retard the soft action of the car spring when going over comparatively smooth roads. They accomplish this by giving the maximum degree of friction when the car spring is completely compressed and by gradually decreasing their friction as the spring returns to its normal position. This allows the car spring to work practically free for a short distance above and below its normal position but checks the recoil from the larger bumps and prevents any severe upward throw of the car body and its occupants.

The two most common means of connecting the shock-absorber to the axle are either steel cables or cotton-web straps. On account of its greater tensile-strength, the steel cable will withstand more severe strains than will the cotton-web strap it is also able to withstand the weather better and to resist deterioration caused by oil or water. The steel cable also simplifies installation, as it requires much less space than a strap that makes it necessary to provide a multiplicity of fittings to obtain the proper clearance of steering drag-links and brake rods.

The advent of the balloon tire has made a tremendous market for shock-absorbers of the one-way type, and it also has made it necessary to build shock-absorbers that do not destroy the purpose of balloon tires and flexible springs by causing excessive restriction over small inequalities in the road.

[1] Abstract of a paper presented before the Chicago Section.
[2] Stromberg Motor Devices Co., Chicago.

WAGE SCALES

SOME years ago the President of the United States remarked, "Under most fortunate conditions * * * there are a million and a half in the United States who are not at work."

Since early in 1924 the general tendency in the manufacturing industries has been to lower rather than to raise wage scales. More than others these reductions appear to have affected the textile, iron and steel and lumber mills. That these changes, however, do not mean any really low rate in industry is evident if the present movement is viewed in the light of conditions revealed by the various surveys of wage rates made by the United States Bureau of Labor Statistics in 1924.

Hourly wages in iron and steel mills were advanced shortly after the general movement to introduce the shorter work-day was begun in the summer of 1923. Even with the shorter working-week in force, the weekly earnings of these workers were still for the most part from 70 to 100 per cent larger than in 1913. Surveys in the woolen and worsted mills, men's clothing plants and cotton mills showed hourly earnings from two and a half to three times those in 1913. The increase in boot and shoe factories and hosiery and knit goods mills was 114 and 138 per cent respectively. The movement to advance wage rates from 10 to 15 per cent in the early part of 1924 was general and these surveys in 1924 in all cases showed rates higher than those in effect when surveys in the same industries were made in 1922. A study of the minimum union-rates covering 900,000 employes in 1924 revealed a gain since 1913 of 128 per cent in the hourly rate.

While the information available is not entirely conclusive, the general movement of payroll totals shows that the average earnings per worker employed in 1925 are, if anything, larger than in 1923. The effects of such unemployment as there is are not aggravated by extensive part-time arrangements for those remaining on the jobs or by sweeping changes in wage scales.—*Commerce Monthly.*

Applicants *for* Membership

The applications for membership received between July 15 and Aug. 15, 1925, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BAINBRIDGE, R. A. H., engineer, salesman and manager, Fiat Motors Eastern India Agency, A. Milton & Co., Ltd., *Madras, India.*

BAINES, W. V., draftsman and sales engineer, 126 Livingston Place, *Bridgeport, Conn.*

BAKER, ROBERT LYNN, service department, White Co., *Atlanta, Ga.*

BATEMAN, P. R., chief of electrical department, Morris Motors, Ltd., *Cowley near Oxford, England.*

BEAUMONT, JAY CHARLES, plant engineer for McGraw plant, Kelsey Wheel Co., *Detroit.*

BETTIS, FIRST-LIEUT. CYRUS, Air Service, Selfridge Field, *Mount Clemens, Mich.*

BJORNBERG, S. O., consulting engineer, Illinois Tool Works, *Chicago.*

BOND, FRANK A., vice-president and general manager, U. S. Chain & Forging Co., *Pittsburgh.*

BRAID, ARTHUR F., sales manager and metallurgical engineer, Metal & Thermit Corporation, *Pittsburgh.*

BROWER, CAPT. GERALD EVANS, engineering division, Air Service, McCook Field, *Dayton, Ohio.*

CATON, JOHN JOSEPH, professor of automotive engineering, University of Detroit, *Detroit.*

CLARK, KILBURN D., National users sales, Buick Motor Co., *New York City.*

CRITTENDEN, P. L., chief engineer, National Brake & Electric Co., *Milwaukee.*

DEVEREAUX, WILLIAM C., president and general manager, Ferro Stamping & Mfg. Co., *Detroit.*

DIXON, WALTER LOUIS, superintendent, International Motor Co., *New Brunswick, N. J.*

DOWNEY, LIEUT. HUGH C., aviator and engineer officer, Air Service, McCook Field, *Dayton, Ohio.*

DUGAN, RAYMOND C., service representative, Olds Motor Works, *Lansing, Mich.*

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FOULOIS, LIEUT-COL. B. D., Air Service, Mitchell Field, *Mineola, N. Y.*

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HARPER, WILLIAM DAVID, Harper Hanger Co., *Boston.*

HARRIGAN, WILLIAM, chief instructor, Knights of Columbus Trade School, *New York City.*

HOLLINGER, W. J., assistant manager of sales and member of executive committee, National Steel Car Corporation, *Toronto, Ont., Canada.*

JETT, GEORGE C., mechanical engineer, Jett & Stiemke, *Milwaukee.*

KERR, J. M., assistant sales manager, Hayes Wheel Co., *Jackson, Mich.*

KEYS, C. M., president, Curtiss Aeroplane & Motor Co., Inc., *Garden City, N. Y.*

KING, PAUL B., airplane test pilot, National Advisory Committee for Aeronautics, Langley Field, *Hampton, Va.*

KRAMER, EILEF F., assistant engineer, Available Truck Co., *Chicago.*

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LEWIS, STEWART P., associate ordnance engineer, Picatinny Arsenal, *Dover, N. J.*

LINDSAY, CHARLES H., service man, Frigidaire, *New York City.*

LUDINGTON, C. T., president, B. B. T. Corporation of America, Philadelphia; president, Ludington Exhibition Co., *Philadelphia.*

MCMAHON, WILLIAM SAUNDERS, laboratory assistant, International Motor Co., *New York City.*

MCNEISH, ROBERT H., automotive engineer, Fire Department, City of Los Angeles, *Los Angeles.*

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MILLER, H. L., shop foreman, Frosaker, Blaisdell & Co., *Minot, N. D.*

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PSCHAIDEN, A. L., draftsman, Graham Bros., *Evansville, Ind.*

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REDMOND, R. W., assistant metallurgist and chief chemist, Olds Motor Works, *Lansing, Mich.*

RICH, BARRET G., machinist, Waterloo Gasoline Engine Co., *Waterloo, Iowa.*

RIEDY, EARL T., draftsman, International Harvester Co., *Fort Wayne, Ind.*

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SCHELLENBERG, ALBERT, designer, Altorfer Bros. Co., *Peoria, Ill.*

SCHMATOLLA, ERNST C., A. C. Spark Plug Co., *Flint, Mich.*

SHULTZ, GLEN, automotive engineer, *Colorado Springs, Colo.*

SMITH, JAMES W., assistant to vice-president and superintendent, Electruck Corporation, *New York City.*

STEPHENS, JAMES H., superintendent of railways, Washington Railway & Electric Co., *City of Washington.*

SWEENEY, JAMES F., branch manager, Mack International Motor Truck Corporation, *Pittsburgh.*

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TOWNE, O. B., commissioner, Asbestos Brake Lining Association, *New York City.*

ULMER, HANS, chief draftsman, Robert Bosch Magneto Co., *New York City.*

VINCENT, EDGAR D., tool engineer, White Motor Co., *Cleveland.*

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WILLIS, GORDON A., department foreman, Morris Motors, Ltd., *Cowley near Oxford, England.*

WUNSCH, JOSEPH W., president and chief engineer, Silent Hoist Co., *Brooklyn, N. Y.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between July 10 and Aug. 10, 1925. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

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